PUNCHES AND DIES

BOOKS

by

F. H. Colvin and F. A. Stanley

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PUNCHES AND DIES

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Layout, Construction and Use

BY

FRANK A. STANLEY

Formerly Editor of Western Machinery and Steel World

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PREFACE TO THE FOURTH EDITION

The present edition of *Punches and Dies,* while carrying much fundamental material, as is the case with the three earlier editions, contains much new matter. Various chapters have been rearranged in order to present additional data in the proper sections in the book and to relocate certain information formerly found in other positions in the volume.

Certain entirely new chapters are included in this revision, and various types of dies of recent development are presented in detail in their proper position in the book. The entire arrangement of the material is now in the form of sections so as to provide a more logical classification of the subject matter and to form a more convenient means of reference in general.

The extension of the use of piercing, notching, and other dies with inserts of cemented carbide marks one of the great advances in press-room practice throughout the sheet-metal stamping industry. These dies, together with details of typical layouts, form one of the important new features covered here. Their productivity and great total life are illustrative of some of the advances in press-tool design and construction. Another important detail covered here is the use of press tools designed especially for stainless-steel piercing and blanking operations. The manufacture of steel cartridge cases, a development based on the necessities of the war, represents one of the striking achievements in the metal-drawing field. It is believed that these new features, with various others not referred to here, will make this volume more useful to the tool designer and die maker and also to the press-room supervisor and operator.

FRANK A. STANLEY

January, 1950

PREFACE TO THE FIRST EDITION

This book has been written with the object of placing before die makers, tool makers, and tool draftsmen, certain definite information not heretofore available as a whole, although some of the material here published is necessarily of a fundamental character with which all mechanics must familiarize themselves in their progress toward a reasonably complete knowledge of the subject of press tools and their construction.

Practically 90 per cent of the material in these pages has been gathered and prepared expressly for this volume and is here published for the first time. The remainder has been selected from current articles originally published by the author and by other contributors to the technical press. For information taken from the latter sources full credit is given under the list of references at the back of the volume.

In gathering photographs, drawings, and data for the preparation of this book the author has been accorded free access to the methods and practice of many of the leading plants of America where he has received the hearty cooperation and assistance of numerous shop executives, tool room foremen, pressroom foremen, die makers and others, and full appreciation of this invaluable aid is herewith expressed. In this connection especial thanks are due the following firms and individuals:

Marchant Calculating Machine Co., E. W. Bliss Co., Smith Premier Typewriter Co., Noiseless Typewriter Co., Westinghouse Electric and Manufacturing Co., Waltham Machine Works, B. C. Ames Co., Henry Disston Sons Co., Aluminum Products Co., American Coin Register Co., Holt Manufacturing Co., Gilro Machine Co., A. H. Marchant, W. Nonamaker, F. B. Shear, A. L. Howes, J. A. Ruffin, W. P. Smith, F. E. Ross, A. B. Swift, H. C. Lockey.

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CHAPTER I

TYPES AND APPLICATIONS OF PRESS TOOLS

Press tools and the metalworking presses in which they are used have been so greatly improved, both in design and in regard to capacity, that no single volume can begin to cover the wide range of operations now falling within their legitimate field in the production plant. The development of our great aircraft industry of itself has been responsible for new tools and methods in this particular field as well as in metalworking processes in general. Wartime necessities led to many improvements in manufacture and gave metal-stamping specialists an opportunity to apply their skill and experience to the solution of many problems presented for the first time to the press departments of factories throughout the country. The automotive industry has been for years a pioneer in the art of tool and die construction and its notable activities in this field will undoubtedly continue to be of increasing importance in outlining the path of progress in metal stamping of many types of parts and in methods of tooling for the purpose.

The last few years in particular have brought into use enormous presses, both mechanical and hydraulic, for large formed and drawn work and higher speed smaller units for light parts of limited dimensions. In fact, small, thin products formerly run at, say, 100 pieces per minute have been blanked and pierced in modern practice at a rate ranging up to several hundred per minute, depending largely on the capacity of feeding equipment to carry the material through the dies and on the means applied for getting the blanks out of the press.

It was considered for many years impracticable to make parts in the form of metal stampings unless they were in large numbers, sufficient to justify the expense of building conventional dies for their production. This situation has been changed in modern practice by the use of short-run tools whereby small lots of work can be handled economically and to advantage in all respects.

As a contrast in the sizes of press tools, compare, for example, the group of dies in Fig. 1 with the big unit on the Keller automatic tool-

room machine in Fig. 2. The punches and dies in the first illustration are part of an outfit of normal dimensions.

On the other hand, the work in the machine in Fig. 2. is one of the largest and heaviest types of press tools used in manufacture. This particular tool under process of being milled is a punch for the entire side of a two-door sedan including the cowl. The form or master for the

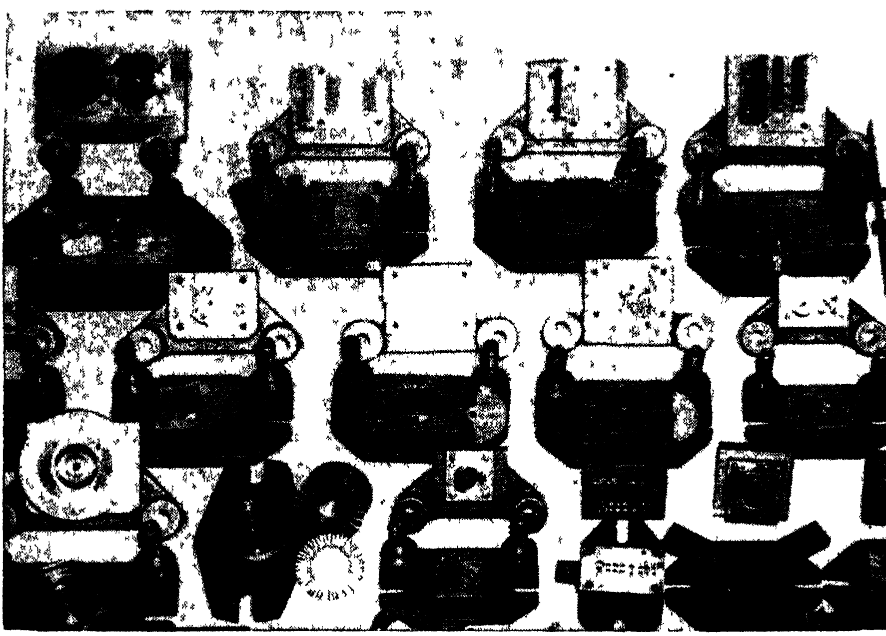


FIG 1 —Press tools for small work

work is at the top of the fixture where it controls the movements in three planes of the contact point and consequently of the milling tools which operate upon the punch or die itself. The machine produces automatically all surface contours and also profiles the door and window openings. This automatic tool room machine from Keller Division of Pratt & Whitney Company, can mill a die impression 10 ft. long by 5 ft. high by 18 in. deep. A still larger machine of this type mills impressions 12 by 6 ft. by 30 in. deep and weighs over 75 tons. The dies produced on such machines are the largest employed in manufacture. The dies alone range up to many tons in weight. Special handling facilities are used in getting them in and out of machines and in moving them about the plant.

Back of all this work are the skilled die maker and designer and the plant's tool equipment. The dies as built are, according to their special purposes, applicable to various sizes and types of presses. Some of

these presses for general usage are adaptable to nearly all classes of work falling within their size capacity. Thus we have the pillar, or straight frame press, the open back and arch types, with single and double crank and inclinable designs of these machines. Then there are drawing presses, single and double acting, toggle and cam actuated, long stroke, hydraulic, and special types.

The work of the die maker becomes more interesting with the progress of manufacture. There are constantly new articles and metal parts to

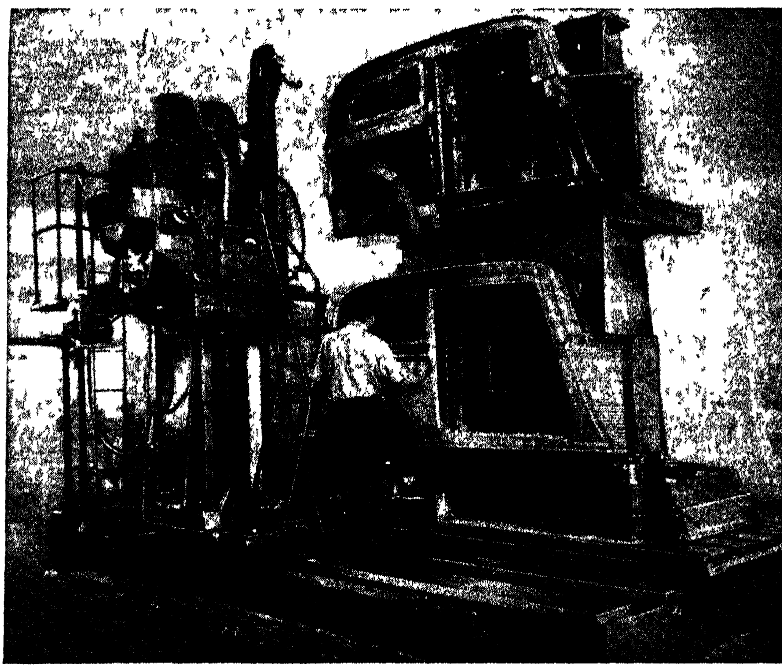


Fig. 2.—Big punch for sedan side cut on Keller (Pratt & Whitney) automatic tool room machine.

be produced in the press, and usually every new item and every older part undergoing improvement or modification in shape or size requires an entirely new set of press tools. There is little repetition of details in most tool rooms so far as die work is concerned, and added to this individual character of the work itself is the fact that requirements as to accuracy in all parts tend to become more pronounced with the development of new products of manufacture.

Influence of the Press Tool on Design

The possibilities of the stamping and forming process have led to a wider opportunity for the designer of many classes of equipment and appliances. Compactness is always possible with the thin metal com-

ponents made in the punch press. Lightness is a feature of such parts, and stiffness is secured regardless of reduced weight, by proper design and the use of suitable material.

Where many elements are to be assembled in limited space, as is the case with so much of our modern apparatus such as business and office machines, radios, household equipment, and other lines, it is difficult to see how the desired ends of compactness, strength, and limited weight of certain members could be attained with any other method of construction than that afforded by the facilities of the punch press when set up with dies adequate to the purpose.

The high productivity of the process, the longevity of the dies with their enormous runs of work before replacement becomes necessary, the extreme accuracy of duplication in all parts coming from the tools, the simplicity of press operation, all lead naturally to a greater extension of this method of metal-parts manufacture.

Certain work that was, for example, formerly produced in the screw machine and possibly milled or otherwise machined in the finishing of certain portions is a press product now; especially in the case of hollow tubular parts which were formerly drilled but which are now formed up from sheet metal instead. Side piercing and trimming can be accomplished in dies, and time saved as compared with drilling or milling. Piercing operations in press tools have been applied to various elements that were drilled under earlier methods. With the advance in die making the possibilities of piercing have been extended, and such accuracy and rapidity are assured as to make the process attractive where the metal is thin enough to permit of proper perforation with the punch.

Accurately Rolled Metal

The accuracy with which sheet metal is rolled today has aided press work greatly. Usually no finishing of side surfaces is required, for the sheet stock is held too closely to gage to necessitate any attention to the thickness of the work, except in rare instances. Light gages of cold rolled steel may run as closely as 0.0005 in. of exact thickness, and slightly heavier metal will be held to 0.001- or 0.0015-in. limit of variation in thickness. These tolerances apply to the narrower strips of metal particularly; with wider stock the thickness tolerance may range a half thousandth in excess of the foregoing figures, especially on the gages of metal $\frac{1}{16}$ in. thick or heavier.

Narrow stock is produced in the form of flat wire and in this form is held closely to width. This enables many parts to be manufactured in the power press without touching the edges in the dies. Thus, many kinds of work can be pierced and cut off, or formed and cut off, from

flat wire of the width required for the piece, thus doing away with the blanking of the outline where a plain edge only is required.

Flat wire of strip stock comes from the mills with edges of various finishes according to requirements. The edge may be round or square according to the character of the piece to be made in the press. In the lighter gages it is often handled conveniently in coils for the purpose of passing through the press tools by means of automatic feeding devices, as single feed rolls or double rolls located either at the sides or at the rear of the press. Where strip stock is hand fed, as is quite commonly the case in the smaller shops, the material is supplied in lengths usually of 12 ft.

A more detailed reference to gages of materials commonly worked in the punch press will be found in other sections. There are a number of grades of cold rolled steel regularly used for specific kinds of press operations, and these are known as "hard," "half-hard," etc. Similarly different "tempers" of brass are produced for various classes of parts. Other sheet materials are regularly handled in the press. These include copper, aluminum, monel metal, duralumin, nickel, tin, and others. Non-metallic sheets such as fiber, rubber, and cardboard are also handled through the press, but special forms of dies or modifications of customary shapes of cutting edges are required for blanking and piercing operations with these materials.

Grouping of Press Tools

Press tools may be divided into certain main groups if we consider first their effect upon the structure of the metal to which they are applied. Thus we have tools that act upon the metal by some form of shearing or cutting operation or by a process corresponding closely to cutting as accomplished, say with blanking, piercing, and shearing dies. Then there are the tools that "work" the metal in the sense that they cause it to "flow," or create a certain slip of the material along itself, a displacement due to stretch or compression or both which, applied directly to the surface of the metal, affects the internal structure as well. Forming and drawing tools are typical of this group; and drawing operations especially, which cause metal to "flow" under tension, present some peculiar problems in respect to the changing body of the object as it is formed up from a flat blank into an elongated shell with walls of cylindrical or other outline.

There are a number of common operations in press work that do not coincide exactly with the above in their effect upon the material, particularly when the metal worked is of very light gage. Thus the bending and simple forming of thin pieces apparently cause very little structural change in the material unless the bend is carried back on itself. Emboss-

ing and coining dies which are applied under heavy pressures create a "flowing" action of the material, the sunken portions of the work providing the metal for throwing up into relief design. But this is again different from the effect produced by the drawing process.

General Classification

The usual classes of punches and dies may be grouped as follows according to the manner in which they are brought to act upon the material, whether steel, brass, aluminum, or other stock:

Class I. *Blanking, shearing and cutting tools.* These perform their work by some form of "shearing" or cutting action, as noted in the

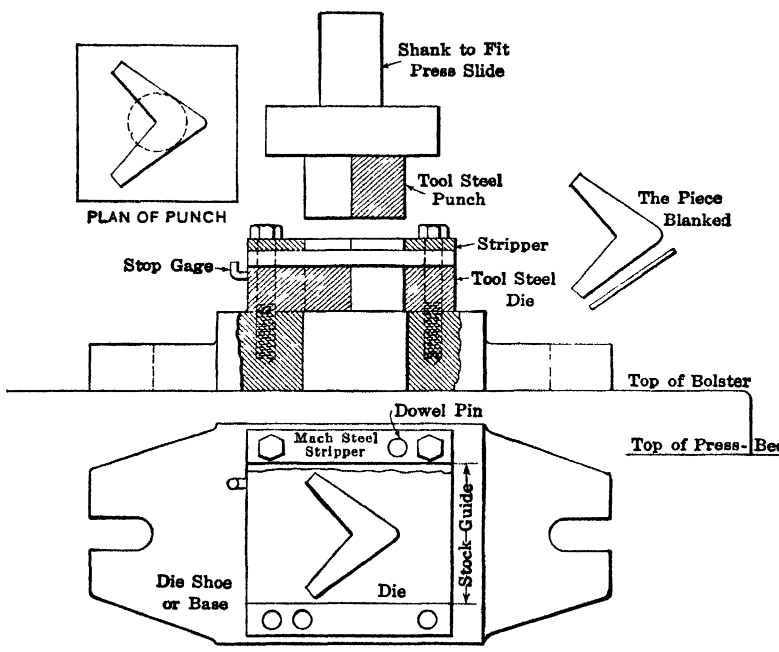


FIG. 3.—Detail of open punch and die.

preceding paragraph. They include cut-off and shearing dies, blanking dies (Fig. 3), piercing, shaving, notching, edging, and trimming tools. The last are applied to the forming of a contour by a series of strokes. For example, a manufacturer uses a punch and die with a short concave form which is applied to the cutting of circular disks, in a rapidly operated press which cuts a short arc at each stroke, the work being revolved by a step-by-step feeding movement to coincide with the movements of the press slide. The radius of the punch and die cutting edges is laid out to produce the desired circular shape without "nicking" into the circle as the work proceeds.

A subdivision of Class I is the hollow cutting or "dinking" die, extensively employed in both press and hand operations for the production of articles of leather, fabrics, cardboard, paper, and other materials. Primarily developed as a hand tool for shaping leather and similar work by striking with a hammer, it is widely used with the same sharp cutting edge in the form of a machine die run in presses at high speed for blanking out many kinds of work from non-metallic sheets. Playing cards, paper-box blanks, cup-leather blanks, and leather and rubber washers, cork disks, toy elements, and many other articles are cut out by such tools.

A similar form of die is frequently used in the platen printing press for blanking out work corresponding somewhat to the items referred to above. The cutting edges of such dies are usually ground to a sharp bevel of say 20 degrees or less, and the opposing member upon which the work is placed and which backs it up for the blanking operation is commonly a hard wood block with the end grain forming the surface to take the cut of the die.

Class II. *Drawing dies and similar tools.* These tools produce the desired shape of work by drawing the flat piece of metal into tubular or other form under an action that causes the material to "flow" under tension. Under this heading are cupping dies, drawing dies, redrawing dies, reducing dies, and bulging dies.

Cartridge cases of brass or copper and many similar articles are produced from sheet metal of requisite gage by cupping, drawing, and similar finishing processes. The cupping dies form a shallow cup preparatory to regular drawing operations. The latter may be several in a series with annealing operations between certain stages of the sequence to prevent undue brittleness due to the drawing process from causing fracture of the shell in the dies. Following the first drawing dies the subsequent tools are redrawing and reducing dies.

While special reference is made here to cartridge-case and allied production as a typical illustration of the application of the drawing process, a great number of articles are manufactured in quantities by drawing dies of one kind or another. Some of these products are far remote from plain cylindrical shells in respect to general shape and character. The sizes of work made in the drawing press range up to large dimensions; and where deep-drawn articles are to be made, presses adapted to such undertakings are required.

With ordinary operations on shallow drawn parts the general-purpose press may be adequate, depending naturally upon the actual proportions of the article, the gage of the stock, and other factors.

Class III. *Bending and forming tools.* These act upon the stock or shape a previously blanked piece by some method of bending, folding, twisting, offsetting, or otherwise reforming a portion or the whole of the

blank usually without actually "drawing" or materially changing the thickness of the metal. In some cases, however, the forming process is closely similar to certain types of drawing operations, the shape of the finished article sometimes necessitating the passing of the blank through an actual drawing process, though this may be for a shallow form only. There is occasionally some overlapping of terms at this point in spite of the fact that die makers generally have rather clear distinctions between their designations for the various classes of press tools.

Bending and forming dies are constructed in different types to suit conditions, volume of work, and size and form of the piece to be produced. This class of tools includes simple and compound types, side-closing dies, and other designs. This side-closing type is used commonly for such an operation as bending or forming an extension or lug over some recessed portion of the punch or to close a blanked piece into some reversed angle against the punch. These are typical cases where a second operation is avoided by the forcing in of two or more side jaws or die sections to form the work against the punch proper which is shaped to the reverse form of the die ends. When the punch rises, the work is carried up by it and is removed either by hand or by a side "knock-off" or pick-off device.

Curling and wiring tools are usually included in the forming class of dies, as they accomplish the operation of bending and forming the end or side of a blank into a circular shape either around a wire or open, according to requirements. Hinge loops are often produced in this manner, and many other sheet metal articles are made in the same way. The circular portion may be curled up by side-closing tools or by forcing the blank down into a concave bottom die where the end of the piece is formed to follow around the interior curve of the die which thus bends it into a full circular curl.

A common application of the curling principle is seen in the production of many kinds of small utensils, cups, rings, basins, and the like where the upper edge is formed over into a rolled bead or curl which provides an attractive finish to the article and also gives a stiffer and more durable edge. Such work is quite apt to be handled in wiring dies which curl the edge of the metal over a wire ring for giving additional strength to the open end of the work.

Class IV. Embossing, coining, and other heavy pressure dies. Such dies cause a "flow" of the metal under heavy pressures which tend to compress the material into the form desired. Heading, riveting, and staking dies also press the metal into the design established by the shape of the tool faces. Extruding dies act in a corresponding manner in displacing the body of the metal under direct pressure. Coining and embossing operations particularly require heavy pressures in order to

force the metal into the design on the face of the tools. The finer lines of relief are brought up clearly only by such pressure, the material displaced by the lower body of the design being thrown up by this "squeezing" action into the higher portions above the original surface of the blank.

The coining press—usually of knuckle-joint or toggle type—is made for a short stroke in most cases, with very powerful action near the end of the downward movement of the slide. Coining and embossing presses are built for pressures up to as high as 1,500 tons. Government tests made at the mints record the following pressures required for different coins: double eagle (gold), 155 tons; eagle (gold), 110 tons; half eagle (gold), 60 tons; dollar (silver), 160 tons; half dollar (silver), 98 tons; quarter dollar (silver), 60 tons; dime (silver), 35 tons; 5-cent piece (nickel), 60 tons; 1 cent (copper), 40 tons.

Compared with some other classes of work the production of coins requires only reasonably heavy pressures, as will be seen from the preceding figures. The knuckle-joint design of press is constructed for such operations as flattening work and swaging as well as for coining, and in all such cases sustained pressure is needed near the end of the stroke to create a flowing movement of the cold metal.

Miscellaneous dies. In addition to the foregoing are a number of tools that are not readily grouped under any of the specific heads already given. Dependent upon their exact application, these may or may not come into a definite group. In some instances they may combine in their action the features of two distinct classes of dies. In this miscellaneous classification may be mentioned the following:

Burnishing or sizing dies. A blank may be forced through a burnishing die which has no clearance for cutting but which provides a very smooth finish for the edge of the piece and sizes it exactly. Or a cylindrical piece can be pushed through a round die for the same purpose.

Straightening or flattening dies. These serve to flatten a blank by striking it between two plain surfaces on the die members, without spreading or thinning the work.

Marking and numbering dies. Serial numbers, symbols, or other characters are struck into the face of the work by suitable stamps inserted in the upper die or punch without forming deep impressions or actually moving an appreciable amount of metal. For serial-marking purposes commercial numbering stamps are used which automatically advance the number with each stroke of the press.

Crimping dies. These are used in various ways for pinching in the end of a shell or the side of a blank to grip some other piece, as in the case of a cartridge shell which is "crimped" into the bullet to hold it in place.

Pinch-off dies. These are really a form of cutting tool in that they trim off the end of a cup which is being drawn through a die. A shoulder on the drawing punch strikes the irregular upper end of the shell as it is drawn down through the die and trims off the rough end by cutting against the beveled die mouth.

Assembling dies. Some classes of press work are assembled in dies as the pieces are blanked out and formed up in multi-stage tools. Certain kinds of chain are handled in this way. Also some types of hinges, bottle caps, and closers and different hardware details and metal specialties. In some instances one of the elements already made is fed from a magazine into position for assembling into place in another piece as it is formed in the press.

Different Types of Tools for the Same Purpose

Nearly all of the dies in the groups described are built to various designs and operated in accordance with their general type or form. A

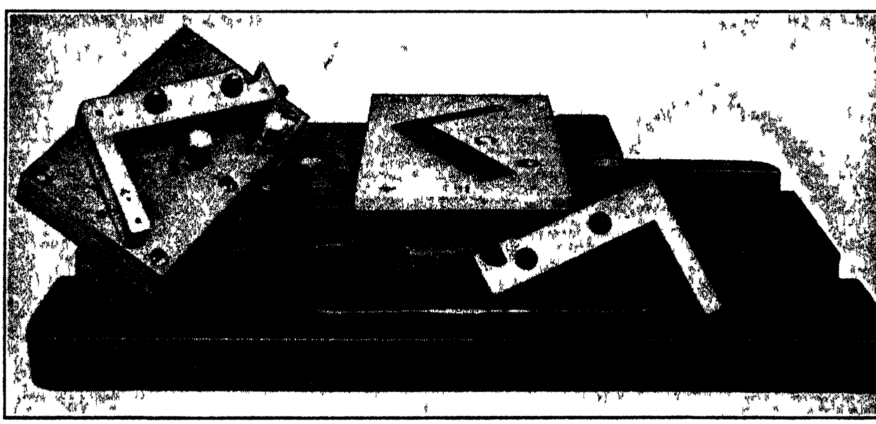


Fig. 4.—Progressive piercing and blanking tools.

set of blanking tools may be simple, open tools in which one blank is produced at each stroke of the press, and the piece pushed down through the die by succeeding blanks as punched out of the strip of metal. Or a piercing operation may be combined with the blanking process; and here the piercing is done at the first stroke of the press, and the stock is then fed along to a second position for the blanking out of the piece. After the second stroke a pierced and blanked piece drops out of the press at each down-stroke of the slide.

Again, a forming or other operation may be combined with a piercing and blanking die; and piercing, blanking, and forming carried on at the same time, with the work progressing from one stage to the next. These tools are called by different terms, as progressive dies, tandem dies, multi-stage dies, follow dies. With such tools the blanking is usually

performed last, the preceding operations of piercing, etc., being done in sequence as the material is fed along, and the blank cut out as the final operation. A progressive piercing and blanking die is shown in Fig. 4, and another set of progressive tools in Fig. 5.

Such dies are rapid producers, as each stroke completes a piece whether two, three, or more operations take place ahead of blanking. They are naturally more expensive to build than the single tools but much more economical to use, as they do away with the necessity of "second-operation" tools for piercing or otherwise handling work already blanked out.

Where small parts are to be made in very large quantities, gang tools or multiple dies may be used for stamping out two or more pieces at each stroke, thus increasing output appreciably over single tools. Where many small holes are to be punched in the work, the gang punches are known as perforating tools.

Punch Shanks and Holders

It may be well at this point to refer to the fact that a set of tools may be placed in the press in different ways. Usually in speaking of a set of dies we include a punch and a die; and as a rule the punch is carried in the slide, and the die secured to the bed or to a bolster on the press. This arrangement is sometimes reversed, and in some instances both members of the set are dies proper and are then known as the upper and lower dies respectively. This is the case with such tools as embossing and some other forming tools and also applies to coining and similar dies, where the design is cut into the faces of the two opposing tools.

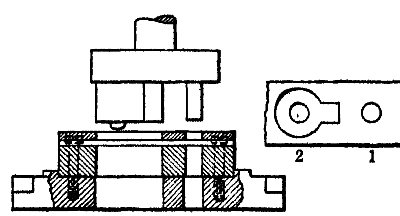


Fig. 5.—Outline of progressive piercing and blanking die.

It is quite usual for press builders to construct the slides of ordinary sizes of presses to receive round shanks on punch holders. In some instances a square opening is provided for holding either round or square shanks. The round shank has become generally adopted for the average run of tools, except in larger sizes where the punch holder or upper member of the die set must be bolted directly to the lower face of the slide. In certain designs of press slides, however, the dovetail form of opening is retained. This admits a punch holder with dovetailed top which is secured in the corresponding guide in the slide.

Along with round punch shanks has come the common practice of using a guide-post design which alines punch and die accurately, keeps them accurate, and retains the punch in correct relation to the die. With

dies of this design the punch or punch holder is readily clamped in the press slide or ram with no possibility of its twisting in service. These guide posts or pins are not always placed at the die corners. It has been customary among earlier die makers to refer to such tools as "pillar dies" and "sub-pressed dies." The latter name is derived from the sub press which is a self-contained unit operated by placing it in the regular press where it maintains its own perfect alinement regardless of the condition of the main press itself. Similarly the sub-pressed or guide-post dies are always in line with each other and are easily set up in the press where they operate without danger of the punch "shearing" into the die and injuring the cutting edges of the tools.

Plain Dies and Others

In spite of the obvious advantages of the pillar type of construction, there are many examples of good dies still made with the plain form of punch shoe and die head where the alinement of the tools must depend upon the condition of the punch press and the accuracy of the "setting-up" operation. For moderate runs of work or where the expense of tools must be held to a minimum, the plain type of die is frequently built and serves its purpose satisfactorily. Where longevity of tools and permanence of accuracy in the product are required, the guide-post type is generally specified. Its service between grinding or sharpening operations is extended, and its ultimate life prolonged to a marked degree.

It is true that with much of the work produced in the punch press the dies may outlast the period during which the design of the piece to be manufactured will remain unchanged. This factor has something to do with the determination of the type of tool best adapted commercially to the work in hand. On the other hand, many kinds of press work are produced in great volume, and many dies are replaced over and over again during the existence of that particular product. In such instances the first cost of the tools is unimportant, as they are soon paid for in regular production runs.

The Sub-press Die Sets

The sub press as manufactured commercially is usually barrel or arch shaped in body with an internal plunger or round slide for carrying the upper tools in the set. As stated, the axial center line of plunger and die base is maintained, and there is no opportunity for the tools to get out of line. The connection at the top of the plunger, as in Fig. 6, forms a flexible means of operation by the regular press slide. Small parts requiring accuracy and clean cut outline such as clock and watch wheels and other small pieces for instruments and corresponding devices led to the design of the sub press originally; and its convenience and

facility for producing such pieces, particularly with compound dies, have resulted in the wide development of the pillar or guide-post form of die, of "sub-pressed" design.

Several manufacturers now produce complete lines of die sets with guide-post (or leader-post) connection between die shoe and punch head. These are built in all sizes for use in presses of different capacities. They are accurately machined ready for the attaching of the steel dies and punches. Among other details, or accessories, available for the die maker using commercial units are springs of various dimensions and weights for pressure pads, stripper plates, and knock-out devices; and socket screws, stripper bolts, die clamps, punch shanks, dowel pins,

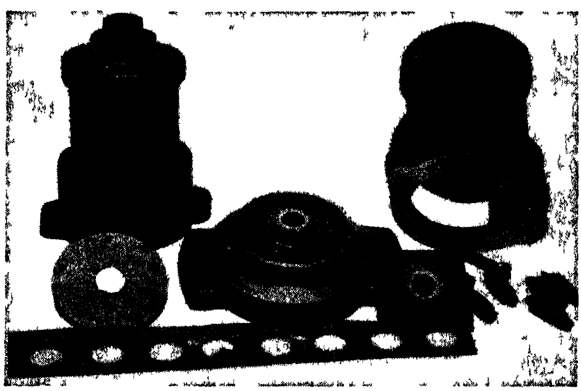


FIG. 6 —The sub press, cylindrical type

and guide posts and bushings of standard dimensions for use with almost any type of die under construction.

Whether regularly manufactured die sets are used or not, the tool maker finds an advantage in being able to secure commercial dowels, leader pins and bushings, accurately produced springs with determined pressure capacities, and other parts that are required for most classes of die work. These eliminate the necessity for much routine work, as is the case with similar parts employed in the construction of jigs and fixtures.

SECTIONAL CONSTRUCTION

Dies are often designed as sectional tools, mainly for two reasons. Sometimes the shape of the part to be made is quite intricate, and a blanking die if made in a single piece might present unusual difficulties in working out, particularly in respect to certain corners, recesses, and angles. It may also be difficult to harden properly without danger of deformation in some important part. In some instances the building up in sections permits the die to be disassembled, ground on worn faces to restore the original size, and rebuilt without difficulty, where a one-

piece die would be impossible to correct when worn beyond the permissible limit.

Larger dies, even of fairly simple form, are necessarily constructed in several sections. Even with medium-sized tools, the practice of using tool-steel working sections with machine-steel backing and carrying portions cuts down the cost of material and frequently simplifies the work of the die maker. Sometimes tool-steel members are secured to cast iron sections where the die is very large; and in not a few instances dies have been constructed with wood blocks faced with metal for doing some kinds of forming work.

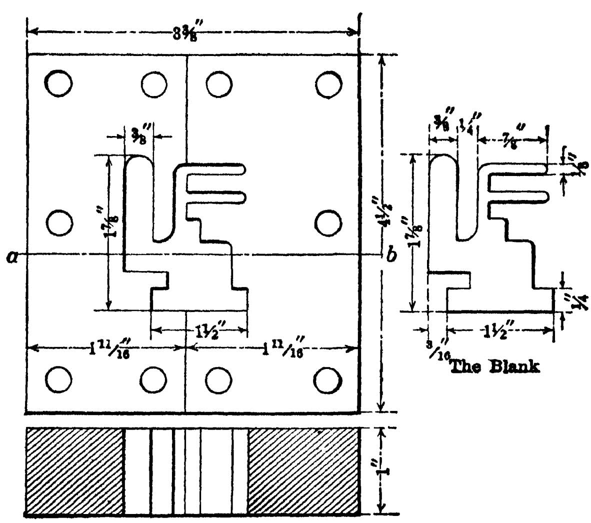


FIG. 7.—Sectional die made in halves.

Two examples of sectional dies of fairly simple design are shown in Figs. 7 and 8. The first is a conventional type of halved die in which both sections are more easily machined out for the die contour than would be the case if the whole die were solid. There are many forms of such dies, some, as stated, with many detail parts. Certain types of this general character will be discussed in a later chapter.

The die in Fig. 8 is a form where two circular surfaces are set together one inside of the other as in a ring. The circumference of the die proper is indexed in making to set for location of the semi-circular openings which are to produce approximately D-shaped holes in the blank at Fig. 9. The outer ring, Fig. 8, in which the central portion of the die is confined provides the arc-shaped edges of the D holes and also blanks out the pierced disk, Fig. 9. The combined operations of piercing and blanking require a compound arrangement of punches and die which is made up with the piercing punches in the upper die member, and the

latter forms the blanking die which matches the blanking edge of punch *C* on the lower die member. Various compound dies are illustrated in another section. The example, Fig. 8, is merely a suggestion of one form of sectional tool design where simpler methods of production are available for making the piercing openings symmetrically about the pattern of the die.

Notching dies for electrical laminations and disks and other similar parts are frequently handled through the press by tools constructed on the built-up order where notched openings are more easily cut from the

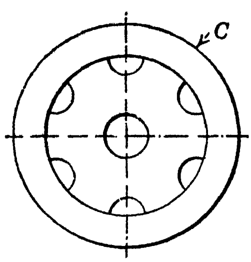


Fig. 8.—Sectional ring die.

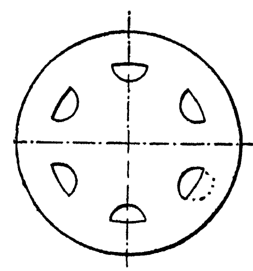


Fig. 9.—Blank made in die in Fig. 8.

exterior of the die center than they could be with a solid form all the way around the notched location.

BLANKING DIE ACTION

Of the various kinds of press tools in service, blanking dies are among the most commonly employed, perhaps the most generally used of all, unless it may be with one possible exception, the piercing tool, commonly called, in elementary form, a punching die. The characteristics of the blanking die and of the piercing die are almost identical in respect to their action upon the work, and we have only to consider a piercing tool of fair diameter as compared with the outside of the blank, to recognize the fact that the piercing punch is merely an internal blanking tool whose purpose it is to form an accurate opening in the stock by cutting out a blank which is, however, discarded as the scrap or "slug" from the punch, just as the material around the outside of the blank is the scrap from the blanking dies.

Considering, now, a simple blanking punch and die or a set of blanking tools or, again, a set of blanking dies, if so preferred, we have in Fig. 3 a typical illustration, a drawing that shows the respective parts of both punch and die, including the bolster upon which the die proper is secured, the stripper which prevents the stock from lifting with the up-stroke of the punch, the stock stop which limits the forward movement of the strip of metal after each punch stroke, and the guide against which

the stock is held to secure straight movement through the die. The sl
of the blank produced is also shown clearly by the engraving.

The Cutting Edges

If we consider the metal to be blanked as very thin stock, it is e
seen that the action of the edges of the punch in respect to the die is
of a cutting tool or, we might say, of a pair of shear blades severing a p
of paper or thin tin. As stock of much heavier gage is taken under
sideration, it is not always quite so easy to recognize the cutting chara
of the press tool edges. But suppose we examine the tools in Fig. 10 f
moment and, instead of passing the strip of metal clear across the fa
the die as in Fig. 3, merely slip the end of the metal over the edg
the die opening as at A, Fig. 10. Now, if the material is fairly heav
compared with the size of the dies, the punch, when it strikes the sur

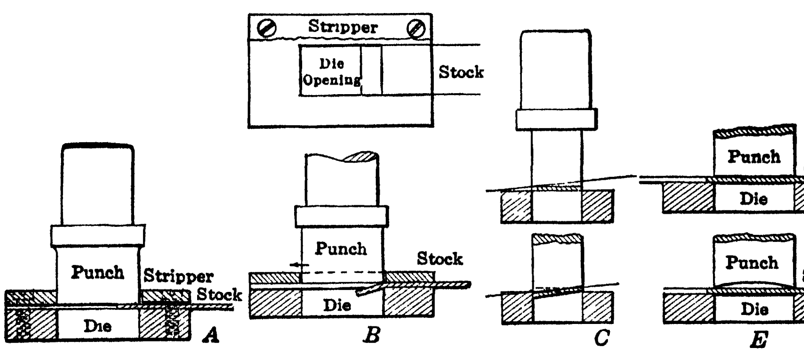


FIG. 10—Action of punch and die on the stock.

of the stock at one side as sketched, will naturally have a tendenc
crowd slightly away from the work in the direction of the arrowhead
bend the end of the sheet metal down a trifle as indicated at B, before
cut can start. If, however, we bevel the face of the punch from fron
back as at C, giving its cutting edge a decided degree of shear, we can
at once that the sheet metal will be readily severed by this very shea
action of the punch edge past the die edges.

Sometimes this device is resorted to, by the die maker, where
tain conditions obtain, although with blanking operations this featu
cutting along one edge only does not of course ordinarily enter in.
referred to here merely for the purpose of illustrating the general e
resulting from an ordinary flat-ended punch striking at one edge onl
heavy gage material. In practice the end of the punch comes d
squarely as at D, cutting out the blank clean and sharp as the pu
edges pass down to the die. With heavy stock, the die maker someti
facilitates matters, as mentioned above, by providing true shearing ac

on the part of the punch from one end to the other or as at *E*, where the end of the latter is slightly concaved. Sometimes the die itself is sheared instead of the punch. This device is more common, however, on piercing punches where heavy plate is punched, the edge of the tool in that case being often made with a spiral contour which shears through the work in a relatively gradual manner.

Piercing Tools

Both plain flat-ended and spiral-cutting piercing punches of this nature are illustrated in Figs. 11 and 12 respectively. The type of die shown in Fig. 12 is generally known as a punch die—sometimes as a button die.

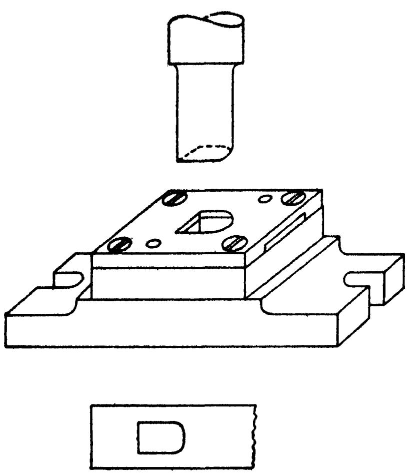


Fig. 11.—Simple piercing die.

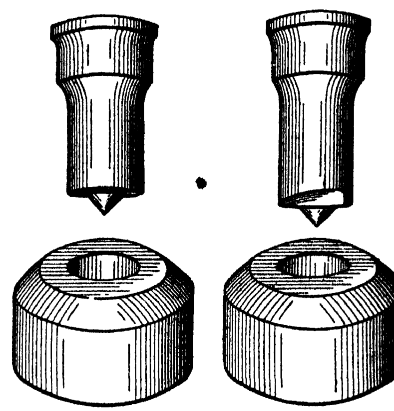


Fig. 12.—Plain and spiral types of punch dies.

Such tools are often made with very small punches which are supported at their cutting ends by passing through a guide plate provided with holes in which the punches are a close fit. Also radial or side-closing punches are made for piercing work through the side. While we are apt to think of piercing dies as used principally for round holes, they are almost as frequently employed for making other shapes of openings, square, oblong, irregular, curved, slotted, etc. Thus the dies that cut out the narrow curved cam slot in the disk, Fig. 13, are piercing tools just as definitely as though they were adapted for making a single round hole in the center of the blank or a series of small holes through any part of the object.

This set of tools, it will be noticed, are of the sub-pressed type, or pillar construction, referred to on a preceding page, the punch and die being held in definite alinement by the upright posts fixed in the die base and

forming guides for the punch block in its up-and-down travel. There are other important features of these tools which will be described at another point in this volume.

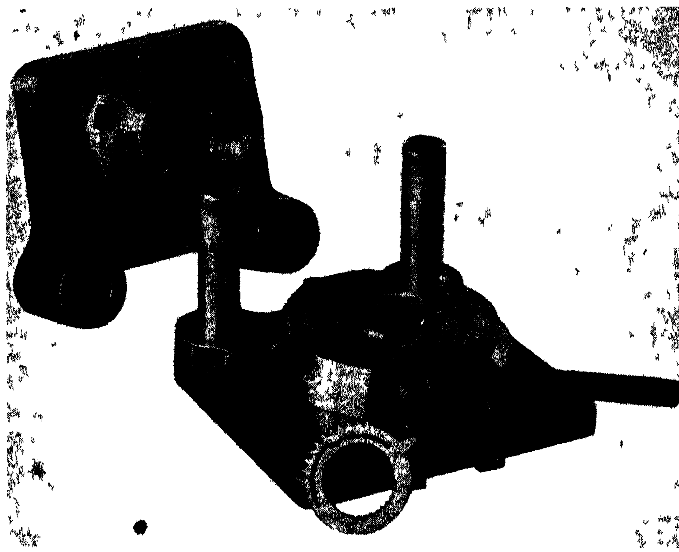


FIG. 13.—Dies for piercing a curved slot.

A number of perforating dies which are for punching many small holes at one time are shown in Fig. 14. These are plain perforating tools without guide pins.

NOTCHING AND COMB DIES

Notching dies, which cut out a series of straight or tapered openings in a blank as in Fig. 15, are other forms of piercing tools used on electrical and similar work. They may cut at one time a complete set of openings around a circle or a segment, or they may be used with an indexing device for piercing out one or more notches at a time.

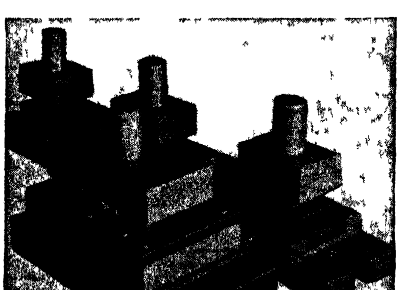


FIG. 14.—Group of piercing dies.

Similarly the dies that cut out the comb-shaped slots in the piece, Fig. 16, are types of piercing devices known usually as "comb dies."

SHAVING TOOLS

Shaving dies are employed on accurate press work where closest dimensions and sharp, clean edges must be maintained on the work.

These may be in the form of external shaving tools for finishing around the outer edges of a blank produced in an earlier operation, or they may be used with equally good results for internal cuts as in finishing the edges of a slot or an opening of any shape produced by piercing tools.

They form one of the most important types of tools for assisting the die maker to secure best results as to accuracy of product. Ordinarily

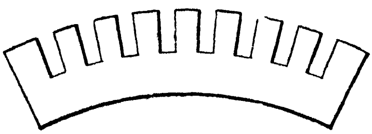


FIG 15.

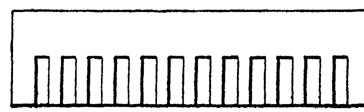


FIG. 16.

they are made to remove a very thin shaving around the edge of the blank, say only a few thousandths at the most, and sometimes reshaving tools are used to follow the first shaving dies, to insure perfectly smooth and accurate edges on the blank. If, in blanking, too small an allowance is left for shaving, it is not always possible to produce a perfectly clean,

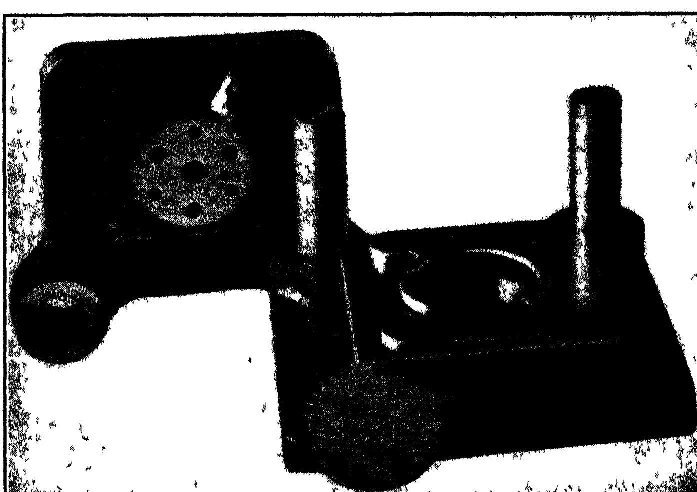


FIG. 17.—A shaving die for a toothed blank.

smooth contour; and, furthermore, a reasonable allowance tends to increase the life of the dies by permitting them to take a clean cut around the blank without likelihood of very thin chips wedging in between the working faces of punch and die.

Shaving operations are usually performed by dropping a blanked piece into a nesting or locating device on the top of the shaving die. Occasionally, however, where only a small portion of a piece requires shaving, as with some important working surface on a piece that is otherwise of

only ordinary degree of accuracy, the shaving operation may be accomplished before blanking by piercing out an opening in the stock around the surface to be shaved, then shaving the accurate portion, and following by blanking out the piece, this method involving the use of a progressive or follow die in which the three operations are carried on at once for as many pieces after the stock has been advanced clear into the dies.

A shaving die of interesting construction is illustrated by Fig. 17, from which it will be gathered that in general appearance the shaving tools closely resemble blanking dies except for the special nesting plate placed over the die proper in place of the customary stripper required for blanking tools.

Cutting-off or Parting Dies

Cutting-off or shearing tools, like others included in press working operations, are constructed in various ways and for various classes of work. In simplest form they are employed for severing flat, round, and other stock and often are fitted with other tools in the same set of dies for cutting off a piece from the strip of stock after certain other operations have been performed.

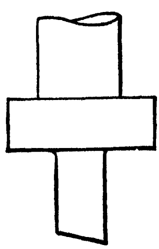


Fig. 18.—Punch with sheared cutting edge.

When made solely for cutting across a piece of metal it is possible for their edges to be given considerable "shear" or slope, as in Fig. 18, to enable them to cut more freely, if desirable. Oftentimes they are shaped to give some special curve or form to the end of the piece cut off and a similar shape to the leading end of the next piece. Thus the tools are made symmetrical, and the same stroke that cuts off the last end of the one piece also shapes the first end of the next, which will in turn be cut off to shape when the stock is fed forward and the punch makes its next down-stroke.

This design balances the cut on opposite sides of the flat-ended punch and allows a single tool to operate on the ends of two pieces at once.

Trimming Dies

Trimming dies are used for cutting off the flange or the extra metal on the ends or edges of articles that have been made by some kind of blanking, forming, or drawing process where an irregular edge or a small amount of metal in the nature of a fin has been left which must be trimmed off to bring the work to finished condition. An example of such tools as applied to a drawn shell with the work ready for trimming and also with the edge finished by passing through the dies is seen in Fig. 19. The punch is so formed as to enter the drawn work and pass it down through the die with the result that the flared open edge is trimmed smoothly all the way round. The cutting action of the trimming

tools is like that of an ordinary set of blanking dies except that the punch is really piloted to enter the work and support it during the movement past the cutting face of the die. Trimming dies are used extensively on flat blanks as well and also for cutting out certain portions of the edges of various classes of parts, round, square, and of other form.

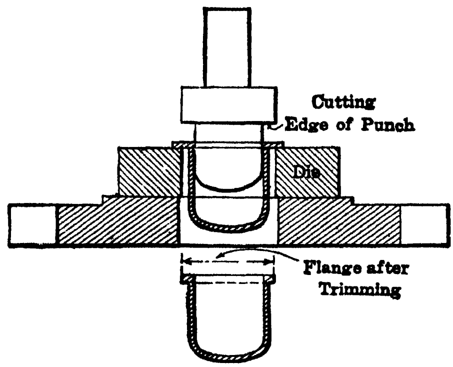


FIG. 19.—A flange trimming die.

An application of the trimming principle to a flanged drawn piece is shown in Fig. 20, where the irregular edge around the flange is indicated as trimmed to the dotted outline. The trimming dies for such operations are essentially in the form of blanking tools.

The sketch, Fig. 21, illustrates a method of producing a blank by the trimming process. Here the stock is cut out from the edges by

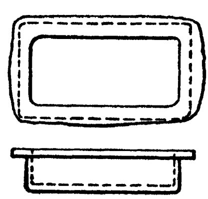


FIG. 20.—A flanged drawn piece to be trimmed.

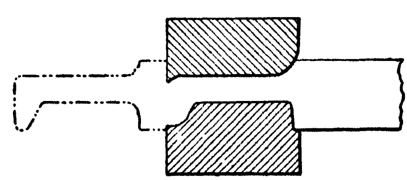


FIG. 21.—Trimming to produce a blank.

trimming dies, and the blanked piece is left attached to the strip of stock to enable other operations to be performed if required. Further dies of this type are shown in detail in the following chapter.

HOLLOW CUTTING TOOLS

The old shop term "dinking dies" applies to a certain type of blanking die which is used for many materials softer than sheet metals. While in principle they are similar to some forms of blanking tools for metal work, they differ in having, usually, a rather keenly beveled cutting edge which cuts through the material—leather, paper, or other—in the same

free manner that, to employ a homely comparison, a biscuit cutter passes through the rolled-out sheet of plastic dough.

Examples of tools for cutting leather and fiber are included in Fig. 22. Their edges, according to the material to be cut, are commonly sloped to an angle of 12 to 20 degrees, and in some cases the interior is fitted with some form of ejecting device corresponding closely to that employed in metal working dies for parts of similar form. The punch is faced with soft brass or wood according to the material to be cut.

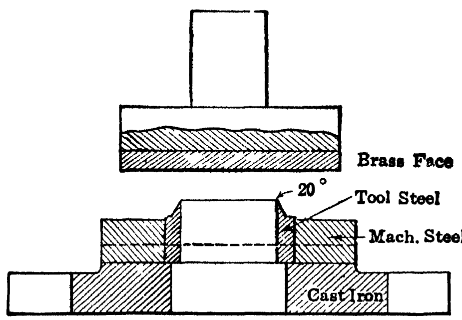


Fig. 22.—Dies for blanking fiber.

The foregoing examples of various kinds of dies for blanking, piercing, shaving, etc., give, in skeleton form, some of the essential elements of the different forms of press tools that operate by cutting or shearing the material. They will be taken up in considerable detail in other sections of this book.

We may now turn to another class of dies, those that operate by drawing or stretching the metal from the flat surface to the special form desired.

THE DRAWING PROCESS

When we take a piece of flat stock, brass, steel, or other metal and push it through a round die by means of a dull-ended punch which cannot cut through the stock, we "draw" the blank into a cylindrical shell; and if our punch and die have been of such size as to allow for the full thickness of the metal between the punch and the interior of the die, the area of the drawn shell will be practically that of the plain disk blank from which it started. That is, the operation accomplished is one of simple drawing without appreciable "stretching" of the original area, although the form of the work has passed through a decided change in which certain elements of the metal have been locally closed or compressed to a degree, and others, directly opposite, stretched correspondingly.

Consider for a moment the thin disk in Fig. 23. Say we have a brass blank A $\frac{1}{16}$ in. thick and of given area; we can force it down through the simplest form of drawing dies at B and produce the cup C which, with certain proportions between punch and die, will have practically the same

total area as the round blank *A*. By repeating the drawing operations with smaller dies and punches we reduce the diameter of the cup and extend the length into a short shell *D* and then into a longer, smaller shell *E*. Still, it is usually possible if necessary to hold the original area of surface, indicating that under such conditions while the metal has been bent, stretched, and compressed, at certain portions, the general body of the metal has not been stretched as a whole.

But in usual drawing processes it is desired to stretch the original metal out as the operations proceed, gradually reducing the thickness proportionately to the length of the "draw," and generally bringing the completed shell to a fairly thin section as compared with the original blank. Occasionally, however, metal is encountered that will not permit of marked if any reduction in thickness by the drawing process, and in such

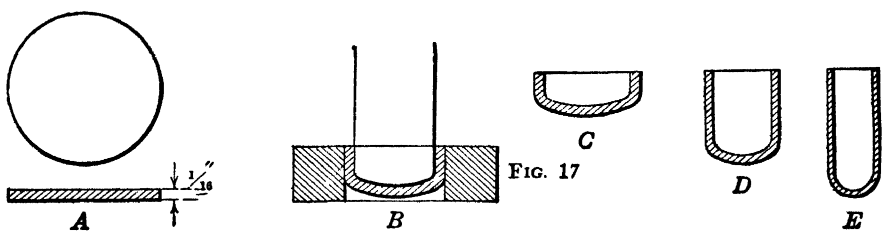


Fig. 23.—Drawing dies.

cases the stock is selected of the same thickness as is desired for the finished product. The drawing or flowing under tension of the thicker metal as it is thinned down by being elongated in the drawing dies tends to harden the material, and with the majority of work where a number of drawing operations are necessary to complete the piece it is essential to anneal the shell between successive draws; otherwise the stock will tear apart, or the bottom of the shell be punched out, an indication of the decided degree of tension to which the material is subjected under usual conditions of drawing.

Action of Drawing Tools

The combined action of the punch and the opposing die surface tends to "iron" out the surface of the metal as it is drawn into the cup form and prevent undue wrinkling during the shallow draw. As the cup is redrawn step by step into longer shells, in successive dies, the reduction in each stage is limited, and with properly made tools undesirable wrinkling is avoided.

Where deep draws are made, and particularly where blanks of the larger sizes are drawn up, the simple drawing tools indicated in the sketch, Fig. 23, are replaced by double action dies which operate in conjunction with a pressure pad for holding the blank under a definite degree of pressure and ironing it out as it is pulled under the pad and down into the

drawing die. Such tools are used in presses which have an outer slide for carrying the pressure pad and gripping the blank, while an inner slide carries the regular drawing punch down into the die.

There is also a class of drawing tools such as combination dies, and another type, compound dies (used extensively also for blanking and piercing), where work requiring shallow drawing may be both blanked and formed or drawn to depth and pierced if so desired at one stroke of the machine, the tools carrying their own pressure pads and being used in simple presses. These types of dies will be described more fully in their proper places.

Reducing Dies

Reducing dies, as pointed out before, are commonly used for tapering and reshaping the end or some portion of a shell that requires a neck smaller than the body of the work. They are considered as a special form of redrawing die, though their action is to close the end of the shell to a certain extent rather than to lengthen the body proper. One of the most common types of dies of this character is that used for reducing the necks of cartridge cases, as in Fig. 24, where a plain taper form is imparted, as at *A*, by the first die, and the neck completed by a second die as at *B*.

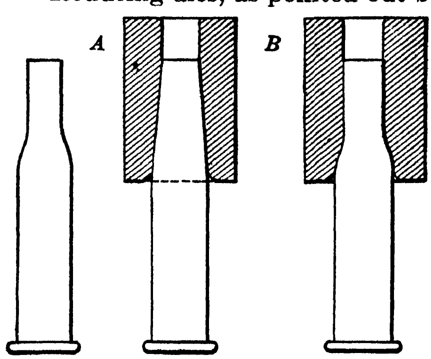


Fig. 24.—Reducing dies.

Bulging Dies

Bulging dies act in the opposite manner to expand the body of an article, as in Fig. 25, where the work is shown placed over a plunger in the die which rests upon a thick body of rubber so that as the punch descends and forms the top of the work to the desired shape, the rubber is forced outward by the compression of the plunger head, causing the shell to expand outward into the die chamber. Upon the up-stroke, the rubber returns to its original dimensions, and the work is removed.

Fluid dies are sometimes used for expanding work into an artistic mold-like device, the liquid being placed in the shell to be formed, and the plunger carried by the press then acting upon the fluid to force the hollow shell into the design formed in the die or mold. Both the mechanical bulging die and the fluid type are employed principally for soft metals and are seldom seen in the general shop, although both types are occasionally used for steel and other relatively hard materials.

BENDING AND FORMING TOOLS

These dies are made in great variety and operate upon all classes of work. In simplest form, say in the case of a plain bending die, the outline of the bend which is to be imparted to the blank is formed on punch and

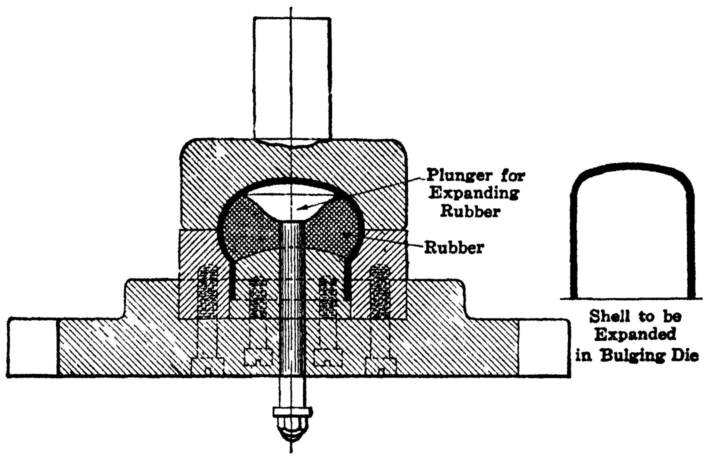


FIG. 25.—Bulging dies.

die, as in Fig. 26, where the method of bending a simple form is indicated. Where a more intricate form is required, as in Fig. 27, a die with jaws that close in from the side is employed to form the ends of the piece over the sides of the punch which controls the inside of the work. Such work is frequently passed through two sets of dies, one for starting the outlines of the bend, the other for completing the work.

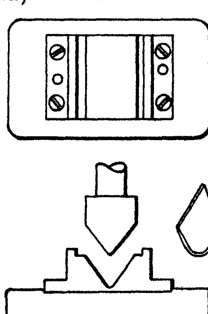


FIG. 26.—Plain bending die.

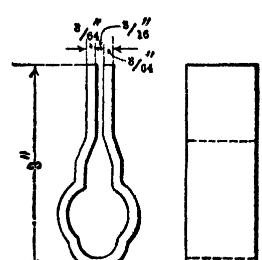


FIG. 27.—Piece formed with side-closing die.

Details of dies for work requiring side-closing operations are covered fully in Chapter XV under the heading of Side-operating Tools.

Where the ends of a flat blank are to be formed up into a curl, as in Fig. 28, similar side-closing jaws or dies are fitted into the die base, and these act to roll over the end of the blank as shown. The die is then strictly a

curling tool; and if it should further include provision for enclosing a piece of wire in the curled portion which is made to roll up around the wire, the tools would become curling and wiring dies.

It is usually a decided advantage and often strictly necessary to start a slight curl on the blank itself when it is produced in the first place in order that it shall curl in the proper direction when operated upon by the curling dies.

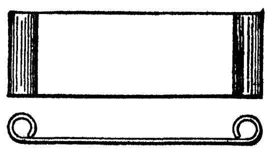


FIG. 28.—A curled piece.

A curling and wiring die for cylindrical work, where a curled edge with wire stiffener is required on a shell or utensil, is represented by Fig. 29.

The construction is practically the same whether or not the wire is required, except that the mouth of the die for the wire may be modified to suit the diameter of the wire as indicated by the sketch.

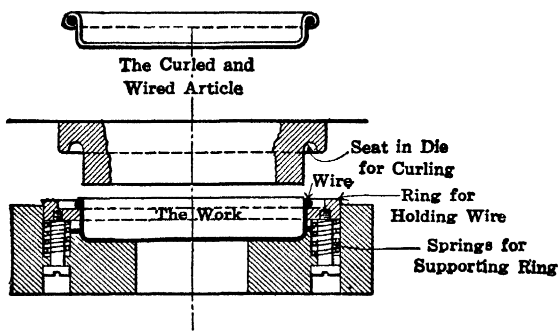


FIG. 29.—Curling and wiring dies.

SWAGING DIES, EMBOSSING DIES, ETC.

Coming now to the class of dies that operate by swaging, or working the metal by upsetting, flowing, and forcing the mass into special forms desired, we may consider first the simple swaging die, Fig. 30. Such dies are used for shaping the edges and corner of blanks already punched out, and in this illustration the swaging dies are for a small handle which is finished properly along its edges by placing it in the dies, thus saving the trouble of grinding or filing corners.

A great deal of work is finished in this manner, the swaging process giving a suitable rounded shape to flat sections and forming corners and edges smoothly and to a neat finish.

Sometimes where numbers, names, or other markings are to be impressed into the surface of a blank the operation is combined with that of swaging. In other cases the characters are stamped on the work before it is blanked out.

A swaging operation under a Zeh & Hahnemann percussion press is represented in Fig. 31, the machine being a design for both hot pressing of

brass and cold pressing of steel and press forging, coining, striking medals, and similar work. The piece in the press is a wedge for tool handles

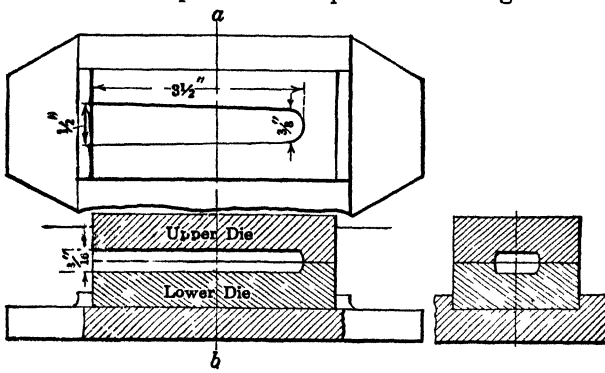


FIG. 30—Swaging dies.

The press produces a cumulative blow, and all of the energy of the fly-wheel is utilized as it comes to a dead stop. The principle of operating the press provides the means of regulating the blow so that over-pressure on the dies is prevented.

FIG. 31.—Swaging wedges on percussion press.

EMBOSSING DIES

There are several distinct types of embossing dies, among the most commonly employed being those used for making jewelry and similar manufactures. The making of such dies is a highly specialized art of itself which hardly falls within the field of the present book. The die proper is struck up from a master or hub which is an exact duplicate of the work to be produced.

Embossing dies, so called, for operating on sheet metal parts are often used in conjunction with blanking tools or with blanking and drawing tools combined. In the latter instance, what are known as triple action dies are sometimes employed, these being operated in a triple acting press.

A set of dies of this character is shown in Fig. 32, in sectional view to represent all parts clearly. The press has double slides above to operate

the blanking punch and the drawing punch inside the latter, and under the die bed is another slide known as a plunger, which actuates the embossing die and forms the impression on the end of the shell drawn up after the drawing punch has carried the work down to the face of the embossing die. The stripping of the finished work from the drawing punch is accomplished on the up-stroke by the edge A.

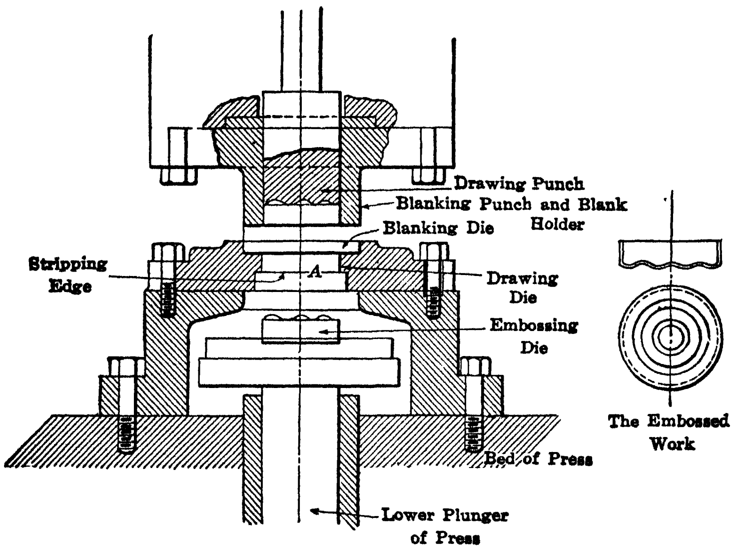


FIG. 32.—Embossing dies.

COINING DIES

Coining dies form another special line of tools and a type which is operated under very heavy pressures in machines of the embossing press class used for striking up jewelry, medals, and many other lines of work where clear cut designs are required in relief on the surface of the object.

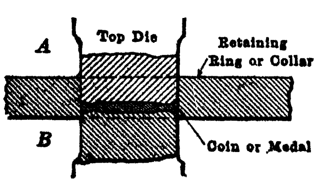


FIG. 33.—Coining dies.

The design for a coin is cut on both upper and lower dies A, B, as represented in Fig. 33, and after the blank C, or planchet, as the coin disk is called, has been struck up, the lower die rises through the collar or surrounding die and carries the completed coin to the top where it is discharged from the press.

HEADING DIES

A common example of the type of die used for heading is found in the tool used for striking up the heads of shells, say for cartridges; and similar articles and dies of this character are most frequently employed in special

horizontal machines, although they are also used in various forms in regular vertical presses. A head formed on a cartridge case by regular heading dies is seen in the illustration, Fig. 24.

Riveting and Staking Dies

These tools are used for fastening parts together and are made in great variety according to the form of the rivet or other fastening device that is to be operated upon. It is the usual custom where the pin, rivet, or post to be fixed is a plain round piece to speak of the tools as riveting dies and, where a square, rectangular, or irregular shape of stud or holding pin is to be "set," to call the tools staking dies. The riveting operation consists in upsetting the end of the pin or rivet sufficiently to hold the parts

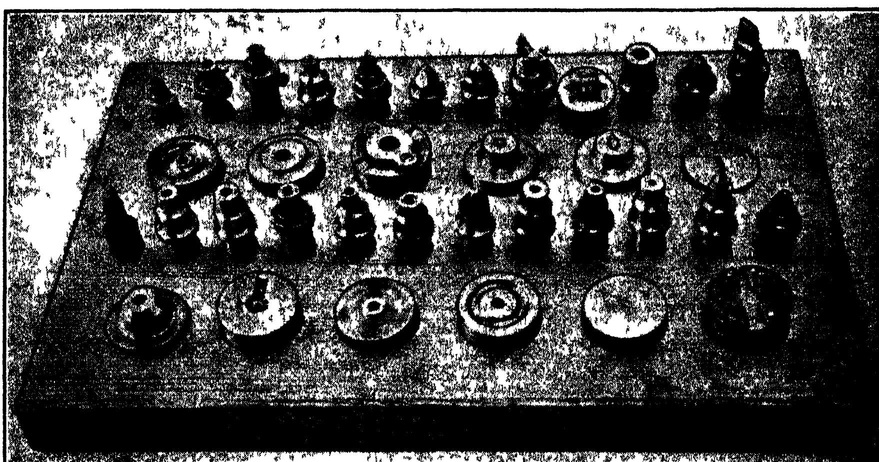


Fig. 34.—Tools for riveting and staking.

securely. Usually staking requires but a single stroke or blow of the punch to spread the metal to hold the pin fast in the hole in which it fits, and generally a staked pin or other piece is flush with the face of the member in which it is set, while with riveting, strictly speaking, the end of the rivet projects above the surface sufficiently to permit of the forming of a regular head under the application of the punch. Both riveting and staking tools are shown in Fig. 34.

Extruding Dies

These tools as considered for punch press operations are employed for such work as forcing out from the flat surface of a blank a pin or other projection which may be needed for pivoting or riveting the piece to some other member. The action upon the material is quite like that of embossing, but for the purpose indicated, the metal caused to protrude

from the face of the work is generally a small pin or plug-like extension. The rivet or plug thus left projecting from the surface is integral with the body of the metal and forms a secure and convenient device for the purpose of locating or fastening the piece to some other part, or for receiving some other member that is required to operate upon a post or stud.

The action of the extruding punch upon the metal is to cause it to flow ahead into the die, and with properly made tools a clean accurate projecting pin is formed which, for various purposes, has many advantages over the more common rivet as usually employed.

It must be noted, however, that there is a limit to the depth to which a pin in any given gage of metal can be extruded. That is, beyond a certain percentage of the thickness of the blank the extruded portion will be forced out as a slug leaving a pierced hole instead of a projecting hub.

Piercing operations, like blanking, require but a short movement of the ram after the punch strikes the work; that is, the punch snaps out the blank (or the slug) without requiring to pass completely through the stock. The distance the punch enters soft steel, for example, to force out the blank has been found to be about as follows:

For soft steel up to about $\frac{1}{32}$ in. thick, or 20 gage, the distance penetrated before snapping out the blank is approximately 85 per cent or 0.027 in.; for $\frac{1}{16}$ or 14 gage the percentage is 75, which equals 0.047 inch; for $\frac{3}{32}$ or No. 8 gage stock the depth is 65 per cent or 0.063 in.; and for $\frac{1}{8}$ gage or 0.125-in. stock the depth entered is approximately 60 per cent or 0.075 in. The thickness of stock thus left to snap through without being actually cut by punch and die varies about as follows: For

$\frac{1}{32}$-in.	metal,	0.004 in.
$\frac{1}{16}$- "	"	0.015 "
$\frac{3}{32}$- "	"	0.030 "
$\frac{1}{8}$- "	"	0.050 "

DEVELOPMENT OF DIE DESIGN

The preceding pages illustrate in conventional form the majority of dies used for general press work of simple character. The illustrations are of elementary tools upon which are based an almost innumerable list of punches and dies for all kinds of purposes in the way of blanking, piercing, drawing, forming, and other typical operations. Such tools have been developed into special forms where a number of operations are performed simultaneously or a number of blanks are produced at one stroke of the press, a number of holes are perforated at one time, or a series of a half-dozen or more operations of varying character are carried out at each stroke of the ram. The modifications and combinations of

primary dies have been carried by skilled designers and toolmakers to a point where no one can set a limit to the possibilities of the stamping process, particularly in regard to the advanced types of presses now built with their capacity for high speed for general production of moderate-sized work, together with the great dimensional capacity of the big hydraulic and mechanical presses introduced into the aircraft and automobile industries.

There are a number of distinct types of dies not covered in the groups shown in this chapter, but in important cases these are described in detail in special chapters, for example, compound dies, combination dies, etc. Tools of the kind mentioned are very accurate and include in a single operation piercing and blanking—as in the compound design—or blanking, drawing, and piercing in the combination type of die. Various modifications and extensions of the different die types shown here are also presented in detail in later sections of this book along with their products and methods of application.

Advances in Metal Stamping

Before taking up in the following chapters a description of the different dies referred to above, it will be of interest to mention certain developments in metal-stamping processes in general, particularly in respect to the making and use of pressed parts.

One of the most remarkable of the advances in pressroom operations is found in the transfer to punch and die jobs of many parts formerly made from forgings or castings. When these parts were so produced, much time was required to finish them in various machining operations and a great deal of expensive material was wasted. In some instances the weight of chips removed was greater than that of the finished article. Moreover, expensive machine tools and special jigs and fixtures were required for doing certain work that might have been produced more simply in the form of stamped parts; if it were impossible to stamp the work as a single piece the several elements as blanked could then be welded or brazed to form the complete unit. While this change-over of certain cast and forged work into pressroom products was going on for many years, the pressure of war requirements led to still further application of metal stampings in place of parts originating in foundry and forge shop.

Typewriter and Other Stampings

Everyone is familiar with the long-time practice of building many typewriter parts of sheet metal stampings and the similar practice in production of other business machines. The manufacturers of cash reg-

isters, adding machines, and allied apparatus were among the first to develop advanced methods in tool and die design and in the application of new types of press tools to rapid production of small sheet metal parts. Press runs on such work have always been very large in volume and any expense for dies whether simple or elaborate in character has been wiped out quickly by the economies due to punch press operations. In many

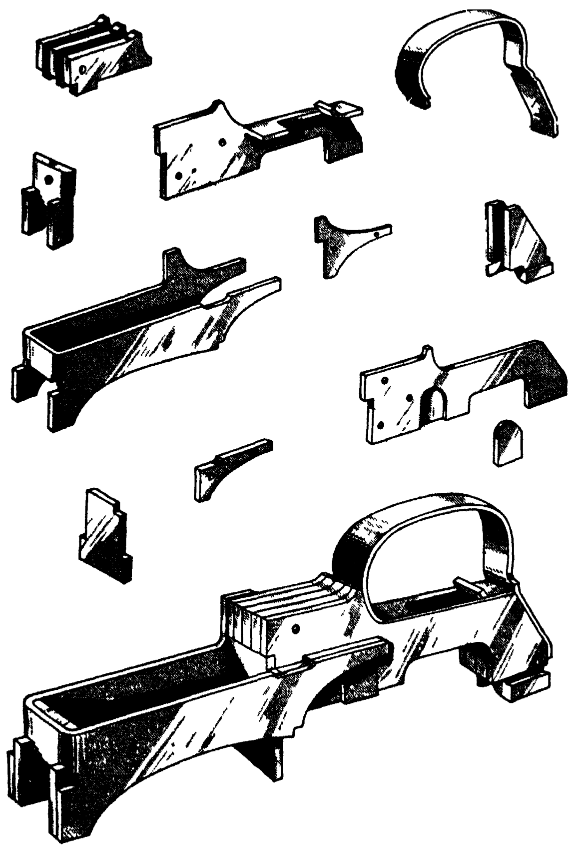


FIG. 35.—These parts of a carbine trigger guard, formerly made from forgings or castings requiring much machining, are now produced as stampings and joined by welding and brazing.

instances millions of duplicate pieces for radios, typewriters, and other office or home equipment have been stamped during the life of a single set of press tools. Hundreds of thousands of parts from ordinary gages of sheet steel are often blanked, pierced, or formed before the dies require regrinding or servicing in any way whatever.

Referring now to the use of stampings in place of many parts formerly made from forgings or castings, an interesting example is presented in

Fig. 35 where a trigger guard for a carbine is illustrated as built up by component parts stamped and then joined by welding and brazing. This is a striking example of a complicated piece of work formerly made from a forging and requiring a great amount of machine work for its production. Much time and material was wasted by the methods used previously. The stamped and joined guard met all requirements in service and the cost was considerably less than the guard it replaced.

Widening the Use of Metal Stampings

Naturally the experience of long-time users of press tools in long-established lines of production mentioned in an earlier paragraph has led to the extension of metal-stamping practice into ever-widening groups of factories where executives have become aware of the many advantages presented by modern stamping methods. While an unlimited number of types of small parts are now made in the form of metal stampings, the most spectacular development in handling of pressed work is to be seen in the forming of the very large parts for the aircraft industry, which has already been referred to briefly in this chapter.

Builders of heavy presses, both hydraulic and mechanical, have developed equipment that is adequate for the requirements of aircraft manufacturers, as well as for other users of large-capacity machines for metal-stamping purposes. In recent years big presses have been used extensively in connection with the Guerin process, as applied to hydraulic equipment in aircraft plants, and builders of these large units have adapted them in many instances for special convenience in handling sheet metal work under this process. Such special facilities may include movable tables by means of which work may be placed at one station while another blank is being formed or drawn to shape under the extremely high pressure of the operating ram or platen.

Big Presses on Aircraft Parts

A big HPM hydraulic press of several thousand tons capacity operating under the Guerin process is shown at the end of Chapter II (see Fig. 91). This method of producing drawn or blanked work in the form of one large piece or several smaller ones simultaneously will be detailed at a later point in this book. It may be stated here that the above process consists briefly in the use of a thick rubber pad and a single die, the rubber forcing the metal over the cutting die edge or the forming die edge. The pad may be some other resilient material instead of rubber, and the die itself is a simple affair as compared with the usual form of matching dies of steel. Particularly is this important in connection with the big work

handled for aircraft and other equipment. The cutting blocks may be as thin as $\frac{5}{16}$-in. sheet metal in the form actually of templates. Metal does not need to be used for forming blocks unless hot forming or strictly high production is required. The resilient pad, or blanket, is carried by the upper platen, or movable member, of the press, the work sheets being conveniently placed on the flat die member on the press bed.

CHAPTER II

PRODUCTION OF METAL BLANKS

Sheet metal blanks may be produced in a variety of ways and by a number of different types of press dies. The method and tools selected will depend upon the number of pieces to be produced and their general character as to accuracy, contour, gage of stock, etc.

For example, a limited number of square or rectangular pieces in a lot can be cut to size with the power shear; and for large sizes of blanks this is the usual procedure even with long runs of work. Or, again, where the pieces are to blanked in the press if they are of large area

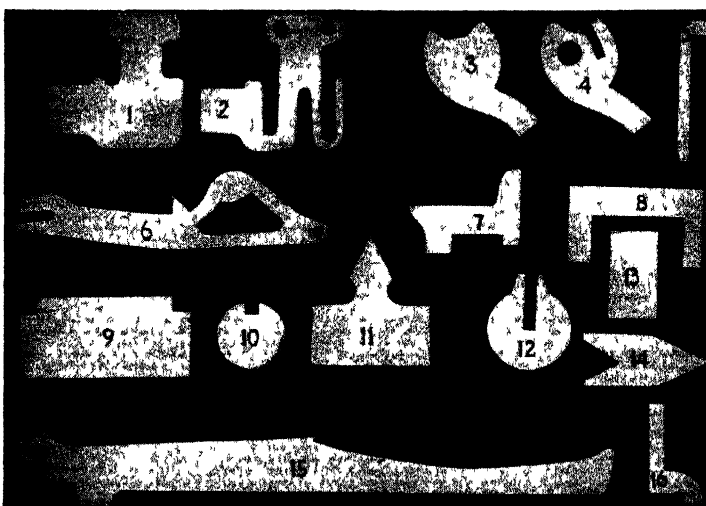


FIG. 36 —Various blanks 1, 2, 3, and 4, sewing machine parts; 5, thin key, 6, adding-machine lever, 7, 8, 9, special shims, 10, key disk; 11, indicator pointer; 12, split washer; 13, 14, tag blanks; 15, type-key lever; 16, small rocker arm.

and therefore wider than the available strip material on hand, they are generally cut out in the squaring shear slightly larger than finished dimensions and then located over regular blanking dies in the press and stamped out to size and shape.

Coming down to smaller sizes of parts which can be blanked from a strip of sheet metal, if the piece is square or rectangular, stock of the right width can be used and merely sheared off to length without other work on the blank than cutting off to length or width. The simplest form of shearing or cutting off die is adequate to the purpose.

Usually, however, something more than mere cutting off of the strip is required. As is the case with most of the examples shown in Fig. 36, the ends or the sides are shaped generally to some special contour; are notched or curved or otherwise designed to vary in some respect from straight line pattern. Where the ends only are of special form it is often economical to make special cut off tools which serve as indicated in the sketches, Fig. 37, to combine the end shaping operation with the cutting off of the blank.

Thus the simple clip blank at *A* is cut off with a trimming punch which leaves the facing ends of two blanks with uniform contours. The semicircular cut at *B* is the result of a round piercing punch and die operating at the point on the strip where the metal will be severed by the shearing die at the next advance of the stock. The notched shim blank at *C* is placed crosswise of the strip of metal, and the rectangular piercing punch cuts out the notch half in one piece and half in the other. The shearing or splitting of the two blanks along their cross center line may be at the next step of the stock as it is fed along, but usually with closely spaced blanks it is more convenient to cut off at a point two steps along the die, as it gives more room for location of tool details and greater freedom in operation.

THE TRIMMING EFFECT

The dies at *D*, Fig. 37, are arranged as trimming tools for producing a blank by cutting out the outline at opposite sides of the stock, the width of space between the trimming edges leaving the body of the blank of the right dimension. The blank while still attached to the length of stock is fed against the stop and sheared off while the next blank is being formed by trimming along its edges. The trimming die is used for many kinds of work and ordinarily is combined with other tools in the same shoe and head for piercing or forming the blank before it is cut off by the shearing tools.

In none of the examples illustrated in Fig. 37 is an actual blanking die shown, although the tools included here are among common types applied to producing blanks. The trimming die especially has its advantages on certain irregular contours where it is effective in cutting away much of the material as a preliminary step to a sequence of finishing stages for completing the piece of work.

Frequently, too, it follows a blanking operation as where some particular surface or projection must be cut in exact relation to a locating point or hole already established in the blank in the earlier operation.

The common blanking die while simple in its elements admits of wide variation in design and construction according to the purpose that it is to fulfill or the quantity of work that it is normally expected to

produce. It is in elementary form about the easiest to build; but for complicated shapes it may involve the application of a large amount of skill and labor if it is to be entirely satisfactory in operation. In its primary form it is an open, push-through type with simple stripper plate covering the material and a simple stop gage for locating the work in position as step by step the length of stock is fed through the press. This gage may be applied to act against the interior edge of one of the blanked openings, or it may be arranged to drop into a notch or gaging hole, the notch usually being pierced at the front edge of the strip of

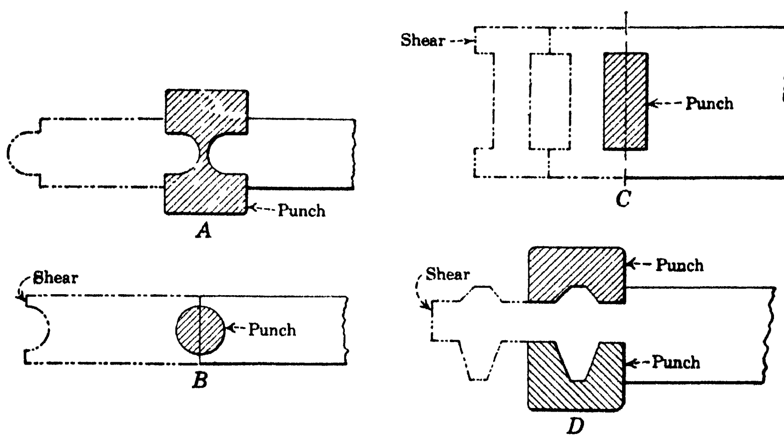


FIG. 37.—Blanks produced by trimming.

stock, or the hole pierced at any convenient position in respect to the width of the strip.

BUILT-UP DESIGNS

Blanking tools are frequently made in sections either because of size or for the reason that complicated die outlines may be more readily shaped in a series of individual blocks machined to fit together and produce in their entirety the complete contour desired. Such constructions have the added advantage that an injured section is readily corrected and replaced; and the entire die does not have to be rebuilt.

With large dies it is a factor of economy in material to follow the built-up method of construction. Only the cutting portion is required to be made of high-grade steel. Machine steel—cast iron sometimes—may form the bulk of the die body to back up the working sections of tool steel. Much depends upon the precise nature of the work to be blanked and upon the anticipated total run of work. The latter is especially important as a factor in determining the amount that may justifiably be expended in production of the set of tools.

Another argument in support of built-up construction on large dies is the adjustable element which is often a feature of such tools. Where plain, fairly large sheets of rectangular form are to be blanked, as for stoves, heaters, and similar articles, it is frequently the case that several different pieces can be handled in one set of tools if it is feasible to adjust an end member or side member of the die by insertion of different cutting sections to produce the desired edge dimensions on the work. Or on such work, locations of notches, hinged portions for covers, and the like may vary as between different sizes of product, yet the one set of dies may meet all essential requirements if it is possible to interchange certain cutting elements along the general contour of the design. The entire series of cutting edges along the outside of the die also may be changed, and the punch elements replaced by others of proportions corresponding to the readjusted die, and thus the one set composed of punch head and die shoe may be used for various blanks within the general type referred to.

This system of accommodation of tools to different sizes of work of this kind occasionally applies to compound dies as well as to the simpler open type used for blanking only. In such cases the interior of the blank may require to be blanked out with a large rectangular opening, and a certain number of holes may be pierced along the sides at the same time. The use of button dies which can be fitted into different location seats along the main die facilitates handling work in this manner.

Different Classes of Blanking Die

Modern die-making practice generally makes use of the progressive type of die for blanking, where a piercing operation is first performed, and the stock is then fed to the second position, and the piece blanked out. This is a two-stage die. In similar tools the blanking operation is oftentimes combined with other operations than piercing or in addition to piercing alone. The dies may be multiple stage with three or four or more steps to complete the blank. There are, however, various reasons why plain blanking is frequently resorted to, leaving piercing and other work for second-operation runs.

For limited amounts of work the cost of the two- or three-stage die is sometimes high as compared with simpler separate operation tools where blanking is followed by piercing in a second operation. While the labor cost of running the work through the press twice is appreciably higher than where the progressive die is used, the length of time involved in short runs of work is comparatively short.

On some classes of work, say where long narrow slots are to be pierced, the slots are sometimes produced in a second operation following blanking, to avoid possible distortion and "dragging" of the slender prong portions

which may occur if slot piercing precedes blanking. Much depends upon the gage of the stock and the general proportions of the slot and surrounding metal (see 1, 2 and 3, 4 in Fig. 36).

On some work of this kind it is possible to trim out a portion of the outline as at *D*, Fig. 37; or, as stated above, a slot may be pierced in the first stage, and the metal blanked out in the second position of the work. If fairly heavy gage metal is to be worked, as is the case with many parts of the class included in Nos. 1 to 4, Fig. 36, it is considered a desirable method to nest the plain blank for a second operation of piercing the slot which on accurate work may require also one or more shaving cuts after the slot has been made.

The heavy-gage, hook-shaped piece in Fig. 38 is another example of a blanked article which may require a second operation for cutting the slot or for shaving it to exact dimensions. On certain work of this character

FIG. 38.—Blanks before and after piercing.

it is possible to blank down against a spring-supported shedder or interior member fitted exactly in the die, which recedes under the pressure of the punch and blank but which supports the blank completely and, rising with the up-stroke of the press, lifts the blank back into the strip of stock with no distortion of the piece.

The majority of the blanks exhibited in Fig. 36 are simple pieces of steel or brass but nevertheless typical of the average run of press work as found in many plants. Number 6 is a member of a business machine mechanism; while 7, 8, 9 are types of shims; 10, a key disk; 11, an indicator element; 12, a slip washer; 13 and 14, tab blanks; 15, a key lever; 16, a small rocker blank.

Several of these are modified in one way or another in later press operations or are pierced or notched in the same dies in which they are blanked. They are in the form shown merely suggestive of a wide variety of small blanks which admit of production in a number of different types of press tools.

There is no limit to the shapes in which blanks can be produced, and the limit as to size seems to be approached only in the case of certain

automobile parts and elements for metal cabinets, furniture, and refrigerator units.

Blanking tools, in elementary form, consist merely of a simple punch and die of the kind illustrated in Fig. 3, in the preceding chapter, but as developed for larger work and particularly for parts of irregular outline, they assume more intricate forms and are oftentimes made up of a large number of sections as stated above, the sectional design having many advantages in first construction and later on in the upkeep. This form of die will be described in detail in the present chapter.

First, however, certain characteristic sets of blanking tools for small parts will be illustrated, such, for example, as are employed for producing blanks similar to some of the pieces represented herewith in Fig. 39. This

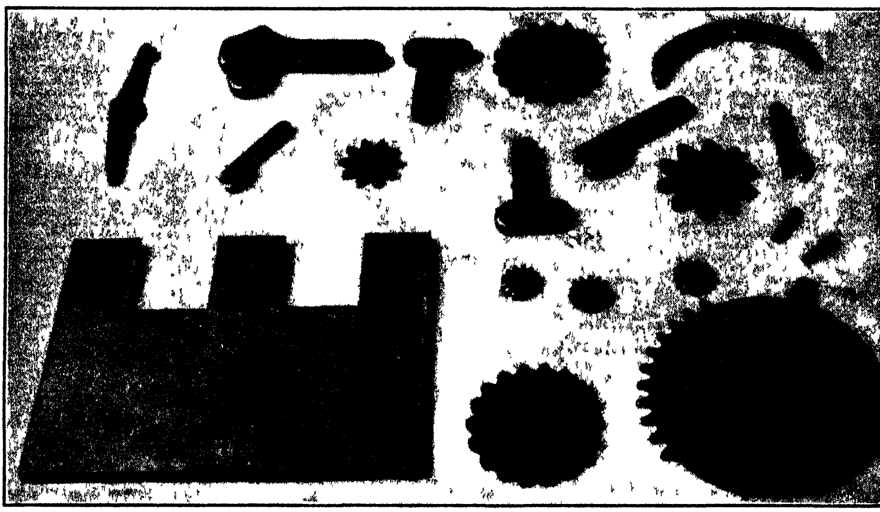


FIG. 39.—Examples of blanked parts.

group of blanks is composed of a variety of small shapes, and as this chapter continues, other and larger pieces blanked by similar means will be shown, in connection with the dies with which they are made.

Blanking and Other Operations

It has been pointed out that blanking operations are often combined with other processes; thus piercing and blanking dies are very commonly combined in the one set of tools, and various forms of blanking and drawing dies, blanking and forming tools, and other sets for performing two or more operations in one pair of dies are used in common practice. The present chapter, however, will be restricted to blanking dies as such, without reference at this point to the numerous forms in which they are made up, as one pair of dies which carry also piercing, drawing, or other tools.

Furthermore, it will be left to another section of this book to illustrate certain interesting examples of blanking dies which constitute first operation tools in complete sets of dies where the blanking process is followed in other tools by such operations as piercing, bending, forming, drawing, and so on. In this connection, the blanking dies will be described in their respective relationship to the other tools in the series, and the effect which subsequent operations have upon the design of the blanking tools will be discussed fully.

We may now take up certain types of blanking dies by themselves and consider various details pertaining to their construction. In order to bring out different points of importance a number of examples have been selected representing the practice of several shops where punch and die-making forms a very large part of the tool room work.

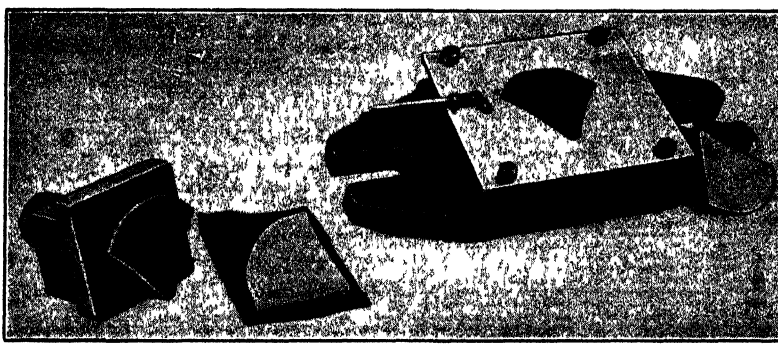


FIG. 40.—A set of open blanking dies.

SIMPLE OPEN DIE

The set of tools in Fig. 40 is for blanking out an aluminum piece of triangular form to the dimensions on the sketch, Fig. 41. The thickness of the piece is approximately $\frac{3}{64}$ in. or No. 16 B. & S. gage. It is a blank which is afterward bent up into a U-form, but the material, gage, and purpose of the blank are of no especial importance here as the illustrations are merely to show a simple form of blanking die, of the open type—that is, without guide pins—and to represent the different parts in detail.

These parts are clearly shown in Fig. 40. The supports for the stripper plate fastened to the top of the die are simply short bushings which hold the stripper at the right distance above the die face and allow the attaching screws to pass through. This is, of course, only one way of spacing the stripper above the die. It is much more common practice to use a strip of metal at front or back or along both edges, to hold the stripper; or to make the stripper from heavier metal and cut out a channel in its underside to allow the stock to be fed through.

Stock Stops

The die illustrated in these views also carries one of the simplest forms of stock stops, a short projecting pin, bent down at the outer end as seen at the left of the die in Fig. 40. This stop is attached to the stripper, and its position is such as to enable its bent end to engage with the openings punched in the strip of material as the blanks are produced one by one and the stock advanced step by step to the left in being fed through the dies.

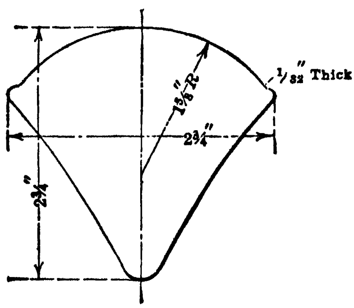


Fig. 41.—The blank produced in the tools in Fig. 31.

The details of stock stops in numerous forms and nests or locating devices for second operation dies are sufficiently important to justify special description which will be accorded them with various other die details in this chapter and in other sections of this book.

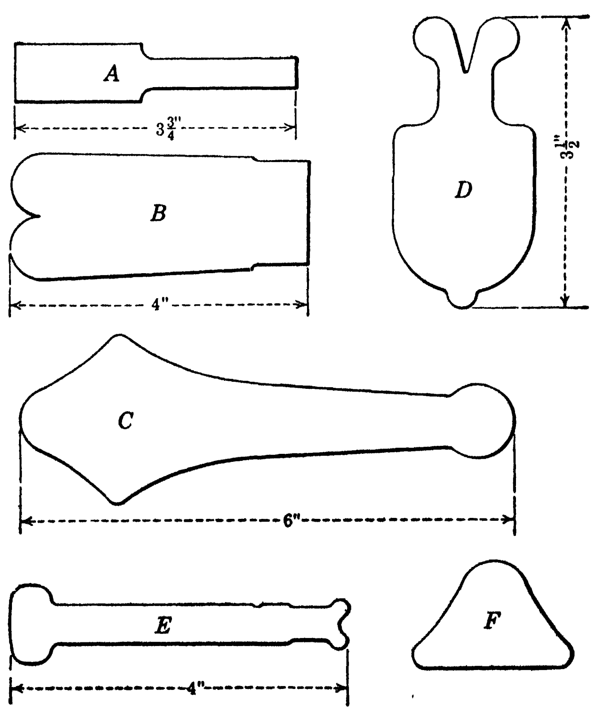


Fig. 42.—Simple blanks made in plain dies.

It will be noticed that the punch proper in Fig. 40 is adapted to be attached to the shank by means of fillister head screws. Here is another

detail in respect to which there is wide divergence in the practice of different shops. A common method is to make the punch, if not too large, with a solid shank if the dies are of the open type here shown and fit the shank either directly into the press slide or into an auxiliary shank or adapter which itself enters the slide of the press. Practice in this respect and with other details of punches and dies will be taken up in due course.

This type of die is used in its general form for many kinds of blanks where large runs are not necessarily handled. For medium-size runs the plain design leads to economy of first cost; and particularly where a design of blank is not fixed for a long period and may require modification, the simple die answers for all essentials.

Characteristic classes of blanks that may be produced by this form of die are shown in Fig. 42. They are merely suggestive of a great variety of work ranging in size and form and in material from which they are blanked.

Description in detail is unnecessary. It may be stated, however, that a very large percentage of press work is of the simple, blanked order, which may or may not require further work in second operations such as piercing, shaving, trimming, etc.

Of the pieces shown in Fig. 42, *A* is a scraper blade to fit into a slotted handle; *B* a double blank for a handle which is afterward formed into shape for use by folding over the center line; *C*, *D*, *E*, and *F* are ornamental plates for hardware fittings and similar purposes.

The gages of stock from which such parts are blanked vary from 12 to 20.

A Pillar Die

Turning now to blanking tools of the pillar type, that is, with guide pins to preserve alinement between punch and die, so that they are operated on the sub-press principle, we have, in Figs. 43 and 44, an interesting example. This is a wheel die for a small toothed blank with outside diameter of $\frac{7}{16}$ in. and 13 teeth. It is of cold rolled steel 0.090 in. thick, or rather heavy metal for so small a blank. Several blanks are included in the group referred to in connection with Fig. 39, and others will be seen in the two tool photographs, Figs. 43 and 44.

The pillar die, or sub-pressed die, is by no means confined to operations on small work of the kind here shown. As already stated, modern practice in press tool work tends to a rapid adoption of this form of die for large as well as small pieces and not only for blanking operations but for shaving, piercing, forming, and other press processes.

The pillar die has indeed become so generally used for a great variety of press work that a majority of the illustrations in this book will be confined to examples of that form of construction.

Wheel Die Details

A drawing of the wheel die, Fig. 43, is reproduced in Fig. 45. This shows all details clearly and brings out distinctly the method of locating the punch in the head or upper member and the die on its base. The former, as will be observed, is made with a flanged circular base and hub to enter the seat bored in the cast iron head; while the die itself is secured by four screws to the lower member or base proper. The punch is positioned by two $\frac{3}{16}$-in dowels, and two $\frac{1}{4}$-in. dowels are used in the die.

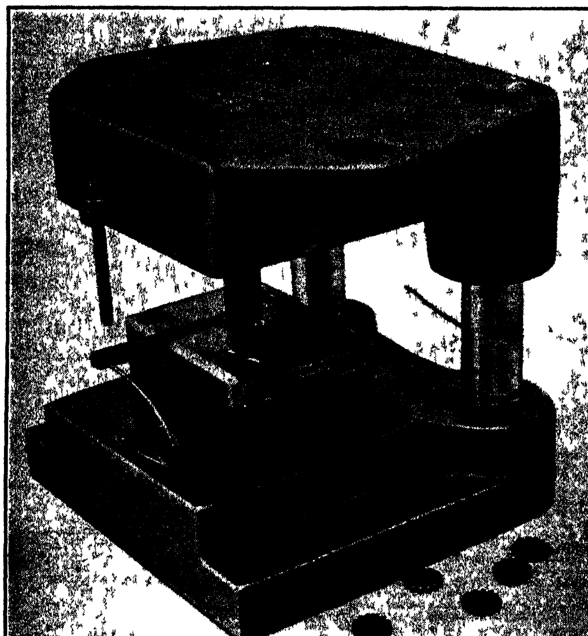


Fig. 43.—A wheel blanking die of the sub-press type.

The stripper is of the type that is made of one piece milled out to form a free passage for the strip of stock. The stock stop is in the form of a rocker or trigger with light spring to hold it down normally with its hooked inner end in the path of the stock. When the press slide descends the contact screw *A* carried by the punch head strikes the stop *B* and causes the inner end to rise so that when the slide and punch start to ascend the stop clears the strip of stock momentarily and permits it to be fed forward to be engaged again by the stop which has been released at the instant the punch has cleared the die.

A single $\frac{5}{16}$-in. by 18-thread screw secures the punch in its seat, the screw having a countersunk head to come just below the face of the holder. The die screws are four in number and are $\frac{1}{4}$ by 20 thread, fillister head

screws. The dowels are ground perfectly straight, and once in place there is no possibility of either punch or die shifting in its seat. Dimensions of all such locating and fastening member for different sizes of dies will be found in another section.

Materials Used

It is not the intention in this chapter to enter into a description of methods of making each and every part of the blanking dies covered by the illustrations. The actual work of the tool room with its high-grade hand and machine processes will, however, be described somewhat in detail later on, not only in connection with the making of blanking tools

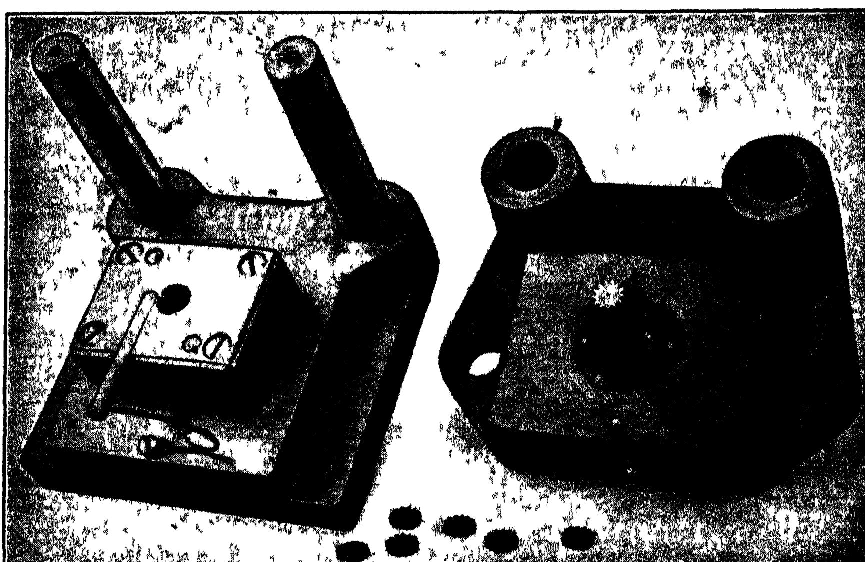


Fig. 44.—Punch-head removed from guide pins

but also in reference to the production of other dies in their various forms.

In the present chapter it is the intention to set forth some general principles respecting the characteristic forms of blanking tools and some of the points that have to be observed by the tool maker who lays out and makes up the dies. These points include such items as the materials required, clearances in dies, allowances for stock in strippers, positions of stops, location of die in respect to the edges of the base in order to place the blank, say, longitudinally with the stock or square across the strip or at some angle to which its contour best adapts it. The interesting process of "finding" the blank, that is, determining its exact outline and dimensions to enable later operations to draw it or form it into a finished article

of the required shape and proportions, constitutes a special subject of itself which will be developed accordingly under its own specific chapter head.

Bases, Heads, and Pins

The tools in Figs. 43, 44, and 45 have die base and head of cast iron, both to standard dimensions in accordance with the sizes given in Chapter

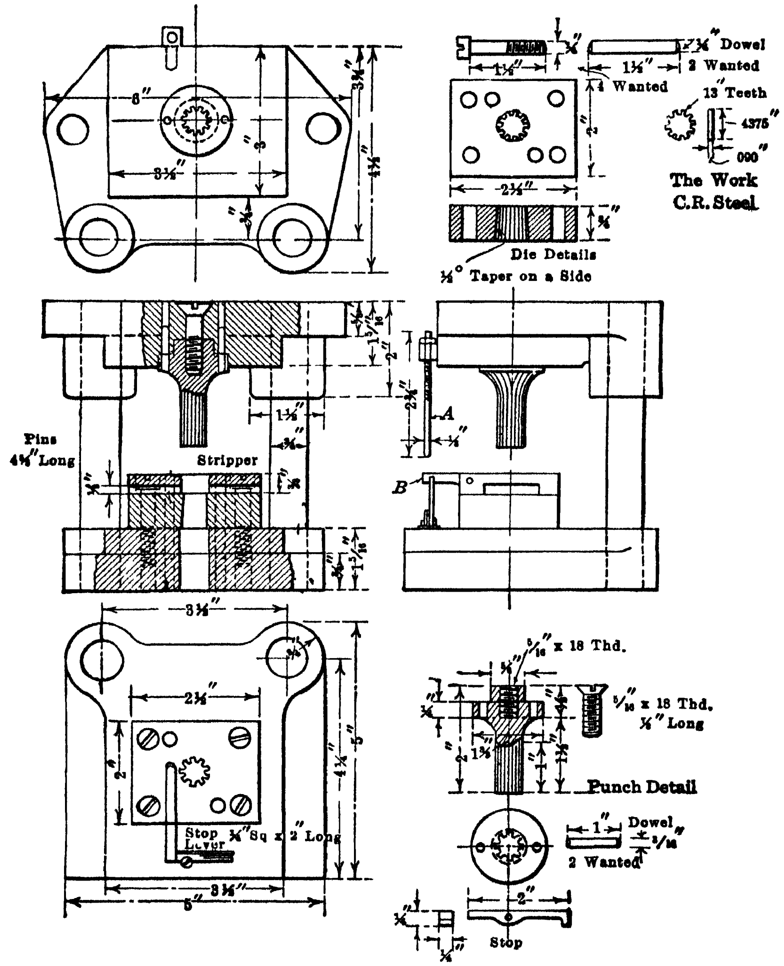


Fig. 45.—Details of wheel blanking die.

XX, at page (2). The pillars, or guide pins, for such tools are usually of a good grade of steel accurately ground to size, which gives them a close sliding fit in the holes bored in the head. Where tools of this form are operated more or less continuously on large lots of work, it is the practice in some places to bush the head and harden, grind, and lap both guide pins

and bushings, thus preserving the wearing surfaces indefinitely and, where replacement of worn parts eventually becomes necessary, simplifying the process appreciably.

Ordinarily, any given set of tools in the press room has a limited run, of a few days say, and then is put aside until another lot of similar work comes along. The rapidity with which such tools produce parts makes continuous operations with any one set of dies a rare event in the general factory. Consequently there is relatively little wear on the guide pins and the corresponding holes in the head, and the surfaces will usually remain in good condition indefinitely.

Blanking Die Clearance or Relief

It is generally the practice in working out a blanking die to allow ½-degree relief or taper on each side as indicated by the sectional view of the die detail in Fig. 45. This will be sufficient in most cases, for slight though the amount of clearance or taper may be, it accomplishes a number of results. It gives, primarily, a gradually increased area of opening in the die to facilitate the passing through of the blanks as cut out without likelihood of their wedging and jamming as successive blanks are forced down upon them; it provides a nominal amount of rake at least, at the cutting edge of the die, and to that degree aids in the free cutting of the blank. At the same time the amount of clearance or taper is so slight that in most cases the increase in the size of the blank as the die is sharpened by grinding across the face is negligible, even though the die is reground many times.

Advantages of Shaving Dies

As a matter of fact, while the factors of natural wear and the grinding off of the die face do necessarily result in a little enlargement of the blank, this is not a serious matter of itself, for the following reasons: In the first place, if blanked parts are to be held to an absolute size, or if their edges are required to be perfectly smooth and with square, unbroken corners, they should be passed through a shaving die in a second operation where they will be brought to exact dimensions and finished with clean, sharp edges. And, assuming that they are to be shaved, the increase in the blank size, due to the condition of the blanking dies, should make no difference, for the shaving process will restore the piece to size even though one- or two-thousandths more are to be taken off than was originally planned for in laying out the shaving tools.

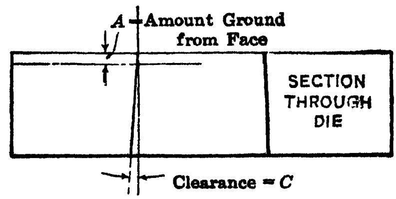
Shaving Dies Especially Serviceable

These shaving dies are especially useful when accurate work is to be maintained in the case of blanks that are rather heavy or of thick stock as compared with their diameter or width. Here, with the heavier material,

it is more difficult to secure accurate, clean contours on the blank, and often not only one but two shaving dies are used after the work is blanked to finish it as required, the amount removed by the secondary operations being divided properly between the two sets of shaving tools.

In the main, however, shaving dies are not extensively employed in the average shop for the reason that sufficiently close results for the greater part of press manufactured pieces are obtainable without them. It is also

TABLE 1



A Amount ground from face of die in thousandths	*C* Clearance in thousandths corresponding to degrees on each side				
In.	½ deg.	1 deg.	1½ deg.	2 deg.	2½ deg.
0.010	0.000087	0.000175	0.000262	0.000349	0.000437
0.020	0.000175	0.000350	0.000524	0.000698	0.000873
0.030	0.000241	0.000525	0.000786	0.001047	0.001310
0.040	*0.000378*	*0.000700*	*0.001048*	*0.001396*	*0.001746*
0.050	0.000437	0.000875	0.001310	0.001745	0.002183
0.060	0.000524	0.001050	0.001572	0.002094	0.002620
0.070	0.000611	0.001225	0.001834	0.002443	0.003016
0.080	0.000698	0.001400	0.002096	0 003092	0.003493
0.090	0.000776	0.001575	0.002358	0.003141	0.003929
0.100	0.000870	0 001750	0.002620	0.003493	0.004370
0.110	0.000960	0.001925	0.002882	0.003839	0.004803
0.120	0.001047	0.002100	0.003144	0.004188	0.005239
0.130	0.001135	0.002275	0.003406	0.004537	0.005677
0.140	0.001222	0.002450	0.003668	0.004886	0.006112
0.150	0.001309	0.002625	0.003930	0.005235	0.006549
0.160	0.001417	0.002800	0.004192	0.005584	0.006986
0.170	0.001484	0.002975	0.004554	0.005933	0.007422
0.180	0.001571	0.003150	0.004712	0.006282	0.007859
0.190	0.001658	0.003325	0.004978	0.006631	0.008295
0.200	0.001746	0.003500	0.005240	0.006980	0.008732
0.210	0.001827	0.003675	0.005502	0.007329	0.009169
0.220	0.001914	0.003850	0.005764	0.007678	0.009605
0.230	0.002001	0.004025	0.006026	0.008027	0.010042
0.240	0.002088	0.004200	0.006288	0.008376	0.010478
0.250	0.002175	0.004375	0.006550	0.008725	0.010915

the case that where shaving dies could be utilized to great advantage in various ways, they are only too often disregarded entirely or are perhaps too little known in some classes of shops to be appreciated at their full worth. In some other shops they are commonly used for both exterior finishing of blanks and shaving pierced openings.

Shaving tools of different kinds will be found illustrated in detail in Chapters VIII and IX.

Table of Die Clearances or Relief

It is sometimes of value to know how much increase in blanking die size occurs as the face is ground down in resharpening, and for this reason Table 1 has been worked out to cover various angles of taper besides the conventional slope of ½ degree on a side. While the half degree taper relief or clearance from vertical line has been specified as almost universally used for the ordinary run of blanking dies, there are special instances where this angle has been exceeded appreciably, and this is true in respect to certain classes of piercing and perforating dies.

While, ordinarily, the angle of ½ degree on a side will allow of the free discharge of the slugs from perforated blanks, such materials as aluminum and similarly soft metals sometimes produce slugs that in the small sizes, particularly, tend to swage into the walls of the piercing die when forced down by the punch; and because of the expanding action, due to the pressure upon their limited areas, these slugs may then stick and stack up and, becoming welded together, are likely to cause the punch to break or the die to become chipped around the edges of the small hole. It is often the case that such slugs emerge from the die in all appearance like a small, solid rod of material, built up of thin disks or slugs pressed firmly together.

The table of various angles with corresponding diameters at different points in the thickness of the die may therefore be of interest in connection with piercing dies as well as blanking tools.

Explanation of the Table

The table is arranged to show the additional amount at each side of a die for every depth of ten-thousandths ground off of its top face. This, by the way, is much more than the average amount removed in one grinding of an ordinary die, but it is a convenient increment to work from, and the quantities in the columns that follow are very readily modified to correspond to any specified amount taken off the die face in the grinding operation.

Consider the half-degree column: The increase at each side of the die is entirely negligible when the first 0.010 in. has been ground from the face, and only after the die has been ground down 0.120 in. or almost ⅛ in.

does the diameter of the die become 0.001 in. greater on each side or 0.002 in. more over-all.

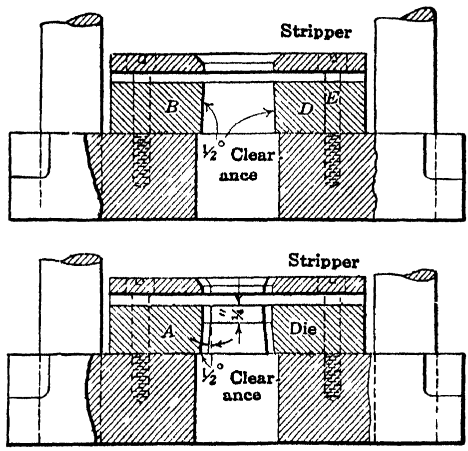


FIG. 46.

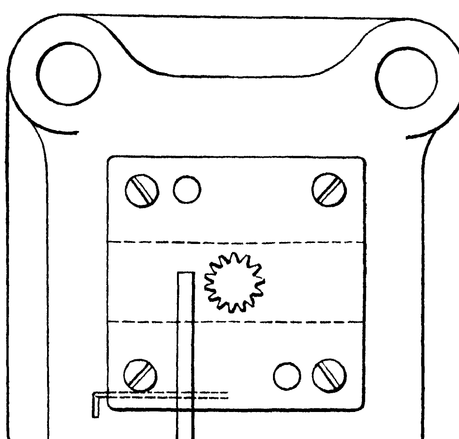


FIG. 47

FIGS. 46–47.—Two methods of relieving dies.

THE LIFE OF A DIE

It is obvious from the table that, even with angles of side clearance greater than the common one of ½ degree, there is little change in the die size until a considerable amount has been removed from its face.

Usually an enormous quantity of work can be produced in a die before its over-size becomes objectionable; and in case the blank is to be shaved subsequently, there is an even greater period of service possible before the slight addition to the blank size has to be taken into consideration.

With fairly small blanking dies, such, for example, as we have been considering for producing the gear wheels in Figs. 43 and 44, it is usually unnecessary to grind off more than, say, 0.005 in. for each resharpening operation. Before grinding becomes necessary at all, at least 30,000 steel blanks will have been produced, and this means that with the same output after each grinding, something like 1,500,000 blanks can be made before the die has been reduced $\frac{1}{4}$ in. in thickness. This is only a part of the entire die at that.

With lighter gage stock and softer material the amount of work blanked in such a die between sharpening operations is greatly increased.

Another Form of Die

This feature of large quantity production between successive grindings enables another form of blanking die to be used occasionally, particularly on such parts as toothed wheels where it may be preferred to have the die perfectly straight for a certain distance up and down, without giving it side clearance in the usual manner.

Such a die is shown at A, Fig. 46, and for ready comparison, the usual die with straight taper inside of $\frac{1}{2}$ degree on a side is shown directly above at B, Fig. 46. The die A, it will be seen, is formed straight down from the top for a depth of $\frac{1}{4}$ in. and below that has the usual angle at the side. The straight upper portion, however, should, in accordance with the figures given above, produce a million and a half pieces before it has been ground to the point where the tapered portion begins, and it thus gives the advantage of a construction where no change occurs in the size of the blanks (except for the unappreciable amount of wear in the die itself) until the actual depth is reached in grinding where the $\frac{1}{2}$-degree taper begins.

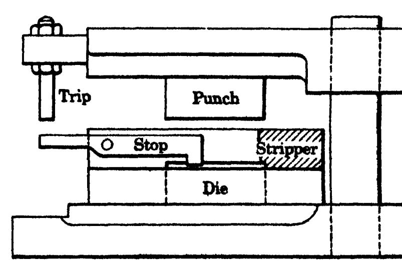


Fig. 48.—Plain stock stop.

It is quite apparent that, eliminating possibility of accidents, such a set of dies would be apt to answer for any but exceedingly long runs of work and in most cases would not require replacement before some modification in the work itself would render necessary a new set of dies throughout.

Some sketches of plain and trigger stop arrangements are shown here in Figs. 48 to 52. These are typical of certain blanking die stops and with the exception of Fig. 49 are automatic in their action in that they are cleared from the strip of stock by the downward pressure on their outer ends when the punch descends. When the punch rises the end

of the stop finger drops into the next blanked opening and serves to stop the strip in right position for the punching of the next blank.

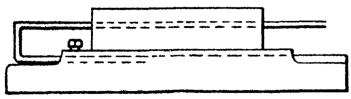


Fig. 49.

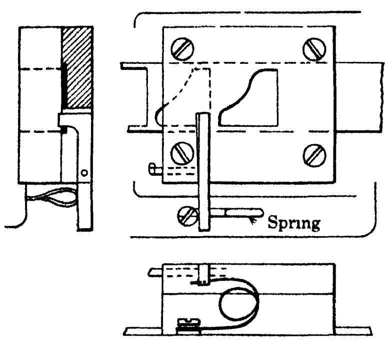


Fig. 50.

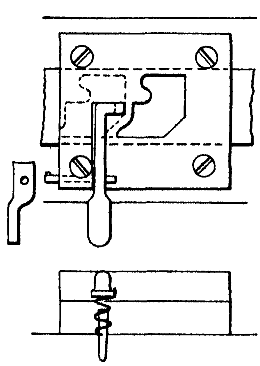


Fig. 51

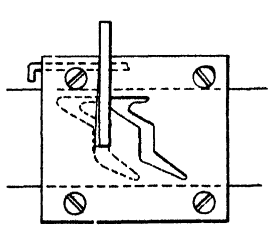


Fig. 52.

Figs. 49–52.—Different arrangements of stops.

The simplest form is at Fig. 49 and is varied by use of a pin, a hooked arm, or any device for obstructing the forward movement of the strip of metal through the dies. The trigger stop, Fig. 50, may be placed in a convenient position along the face of the stripper to contact with its bent end in a blanked opening in the work. Sometimes it is desirable to use an offset contact end as in Fig. 51, particularly where it is preferred to stop against the central portion of the stock along an irregular contour such as is shown in the sketch.

The stop trigger may be set at the rear of the die instead of toward the front. This is indicated in Fig. 52. Or it may be fitted in at an angle as is sometimes desirable where it will clear guide posts, screws, or other parts to advantage. Two different kinds of springs are shown under the outer ends of the triggers. The simplest is seen in Fig. 50, and this spring is shown in many other examples of die stops. In either case the spring is set to crowd the outer end of the stop to the left and swing its working end to the right.

The trigger fits freely in the slot in the stripper plate, and tapered side clearance is provided in the slot toward the inner end. When the strip of stock is pressed against the stop the latter is pressed against its bearing surface at the left side in the stripper; but when its contact end is raised from the stock by the descent of the punch holder the clearance at the inner end of the slot allows the side pressure of the spring at the front end of the stop to force the inner end of the stop to the right

and cause it to drop on to the face of the strip of stock as the punch rises; then the strip is readily fed along until the stop end drops again into a blanked opening.

Clearance between Punch and Die

Theoretically a blanking punch is not supposed to enter the die opening when in operation but to stop at the end of the down-stroke of the press slide with its lower end practically flush with the face of the die. There is a definite percentage of clearance between the punch and the die, the punch being smaller by an amount dependent upon the thickness of the stock and the character of the material, whether hard, soft, etc. On very small work and where very thin metal is blanked, the punch is nominally the size of the die. But with heavier stock the clearance between punch and die becomes an appreciable quantity.

For any given kind of sheet metal the amount of clearance allowed between punch and die is based upon the thickness of the metal and varies directly with the gage of the stock. Considered in respect to different classes of material, the clearance is greater for hard rolled steel than for soft steel and brass. For very large dies there is a greater percentage allowed for clearance than for small dies, but for the general run of sizes there is close uniformity for any specific grade of work.

There must not be excessive clearance in any case, for this may result in slight curling up or bending of the edge along the blank and prevent a smooth, even cut from being produced. Table 2 has been computed to cover clearances for all gages of material in the three gage standards commonly used for sheet metal.

Table of Clearances between Punch and Die

This table has been worked out to give clearances based upon various percentages of stock thickness ranging from 5 to 12 per cent. The first column is arranged to advance by increments of 0.005 inch, and directly opposite, under the respective gage headings, are grouped the actual gage equivalents most closely corresponding to the thickness in the first column.

Of the six columns of clearances, the first three are particularly adapted to very accurate work and small parts especially, 5 per cent being the allowance computed for brass and soft steel; 6 per cent for medium rolled steel; and 7 per cent for hard rolled steel. Similarly, the other three columns cover the general run of work where a little more clearance is permissible, 8 per cent being here allowed for brass and soft steel; 10 per cent for medium rolled steel; and 12 per cent for hard rolled steel.

Table 2

	Gage						Clearance between blanking punch and die based upon percentage of stock thickness					
	American or Brown & Sharpe		U. S. Standard for plate		Birmingham or Stubbs							
	No.	Thickness	No.	Thickness	No.	Thickness	5%	6%	7%	8%	10%	12%
	40	0.003144										
	39	0.003531										
0 005	38	0.003965					0.00025	0.0003	0.00035	0.0004	0.0005	.00006
	37	0 004453										
	36	0.005										
	35	0 005614	38	0.00625	36	0.004						
	34	0.006304	37	0.006640	35	0 005						
	33	0.00708	36	0.007031	34	0 007						
0 010	32	0 00795	35	0 007812	33	0 008	0 0005	0.0006	0 0007	0 0008	0.001	0.0012
	31	0 008928	34	0.008593	32	0 009						
	30	0 010025	33	0.009375	31	0 010						
	29	0.011257	32	0 010156	30	0.012						
			31	0.010937								
0.015	28	0.012641			29	0 013	0 00075	0 0009	0.00105	0.0012	0.0015	0.0018
	27	0.014195	30	0.0125	28	0.014						
			29	0 014062								
	26	0.01594	28	0.015625	27	0 016						
0 020	25	0.0179	27	0 017187	26	0 018	0.0010	0.0012	0.0014	0.0016	0.002	0 0024
			26	0 01875	25	0 020						
	24	0.0201	25	0 021875	24	0.022						
0 025	23	0.022571	24	0 025	23	0.025	0.00125	0.0015	0 00175	0 0020	0.0025	0.0030
	22	0 025347	23	0.028125	22	0 028						
0 030	21	0 028462					0.00150	0.0018	0 0021	0.0024	0 0030	0 0036
	20	0.031961	22	0.03125	21	0.032						
0 035	19	0 03589	21	0 034375	20	0 035	0.00175	0.0021	0 00245	.0028	0 0035	0 0042
0 040	18	0 040303	20	0 0375	19	0.042	0 002	0 0024	0 0028	0 0032	0 004	0 0048
0 045	17	0 045257	19	0 04375			0 00225	0 0027	0 00315	0 0036	0 0045	0 0054
0 050	16	0 05082	18	0 050	18	0 049	0 0025	0.0030	0.0035	0 0040	0.0050	0 0060
0 055	15	0 057068	17	0 0562			0 00275	0.0033	0 00385	0 0044	0.0055	0 0066
0 060					17	0 058	0 003	0.0036	0 0042	0.0048	0.006	0 0072
0 065	14	0 064084	16	0 0625	16	0 065	0.00325	0.0039	0.00455	0 0052	0 0065	0 0078
0 070	13	0.071961	15	0 070312	15	0.072	0 0035	0 0042	0 0049	0.0056	0.007	0 0084
0 075							0 00375	0.0045	0.00525	0.0060	0 0075	0 0090
0 080	12	0.080808	14	0 078125			0.004	0.0048	0.0056	0.0064	0.008	0 0096
0 085					14	0 083	0.00425	0.0051	0.00595	0 0068	0.0085	0 0102
0.090	11	0.090742					0.0045	0.0054	0.0063	0 0072	0.009	0 0108
0 095			13	0.09375	13	0.095	0.00475	0.0057	0.00665	0 0076	0.0095	0 0114
0 100	10	0.10189					0.005	0.0060	0.007	0 0080	0.010	0 0120
0 105							0.00525	0.0063	0.00735	0 0084	0.0105	0.0126
0 110			12	0.109375	12	0.109	0.00550	0.0066	0.00770	0.0088	0.011	0 0132
0.115	9	0.11443					0.00575	0.0069	0.00805	0.0092	0.0115	0 0138
0 120					11	0.120	0.006	0.0072	0.00840	0.0096	0.012	0 0144
0.125			11	0.125			0.00625	0.0075	0.00875	0.0100	0.0125	0.0150
0 130	8	0.12849					0.00650	0.0078	0.00910	0.0104	0.013	0.0156
0 135					10	0.134	0.00675	0.0081	0.00945	0.0108	0.0135	0.0162
0.140			10	0.140625			0.007	0.0084	0.00980	0.0112	0.014	0.0168
0.145	7	0.14428					0.00725	0.0087	0.01015	0.0116	0.0145	0.0174
0.150					9	0.148	0.0075	0 009	0.01050	0.0120	0.015	0.0180
0.155							0.00775	0.0093	0.01085	0.0124	0.0155	0.0186
0.160	6	0.16202	9	0.15625			0.008	0.0096	0.01120	0.0128	0.016	0 0192
0.165					8	0.165	0.00825	0 0099	0.01155	0.0132	0.0165	0.0198
0.170			8	0.171875			0.00850	0.0102	0.01190	0.0136	0.017	0.0204
0.175							0.00875	0.0105	0.01225	0.0140	0.0175	0.0210
0.180					7	0.180	0.009	0.0108	0.01260	0.0144	0.018	0.0216
0.185	5	0.18194					0.00925	0.0111	0.01295	0.0148	0.0185	0.0222
0.190			7	0.1875			0.00950	0.0114	0.01330	0.0152	0.019	0.0228
0.195							0.00975	0.0117	0.01365	0.0156	0.0195	0.0234
0.200							0.0100	0.0120	0.01400	0.0160	0.020	0 0240
0.205	4	0.20431	6	0.203125	6	0.203	0.01025	0.0123	0.01435	0.0164	0.0205	0.0246
0.210							0.01050	0.0126	0.01470	0.0168	0.021	0.0252
0.215							0.01075	0.0129	0.01505	0.0172	0.0215	0.0258
0.220			5	0.21875	5	0.220	0.0110	0.0132	0.01540	0.0176	0.022	0.0264
0.225							0.01125	0.0135	0.01575	0.0180	0.0225	0.0270
0.230	3	0.22942					0.01150	0.0138	0.01610	0.0184	0.023	0.0276
0.235			4	0.234375			0.01175	0.0141	0.01645	0.0188	0.0235	0.0282
0.240					4	0.238	0.01200	0.0144	0.01680	0.0192	0.024	0.0288
0.245							0.01225	0.0147	0.01715	0.0196	0.0245	0.0294
0.250	2	0.25763	3	0.250	3	0.259	0.01250	0.0150	0.01750	0.0200	0.025	0.0300

These clearances apply to piercing dies as well
In blanking, the die, of course, determines the s
the allowance between punch and die must b
being made to the size required for the
smaller according to the allowanc
shaved after blanking, the allow
the size of the blanking die
corresponding amount.

In reference to the si
be pointed out here th
the die to the ex
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table opposite the thickness of stock by the actual
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ᐢuted for gages in the U. S. Standard Plate
· under these gage numbers correspond
·erican or B. & S. gage and the Bir-
earest thickness in the table the
· mentioned are easily located

ᐟNG BRASS AND STEEL FOR

35,000 lbs.
ᐢ,000 lbs.
ᐢ00 lbs.

ᐟh-carbon ᐟteel
70
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in the table. A similar table for piercing dies, but based upon a 1-inch diameter of hole, will be found in the chapter on Piercing Tools.

The Effect of Sheared Tools

Where the tools are sheared, that is, beveled off from one side to the other to give a gradual sloping cutting action, the pressure required is much less than given in the table and may usually be taken at one-half of the pressures for flat tools for stock not over, say, $\frac{1}{4}$ in. thick. Beyond that a safer amount would be two-thirds of the pressure necessary for dies without shear.

The action of the sheared face punch has been referred to in connection with Fig. 10 in Chapter I. Blanking punches of considerable length of

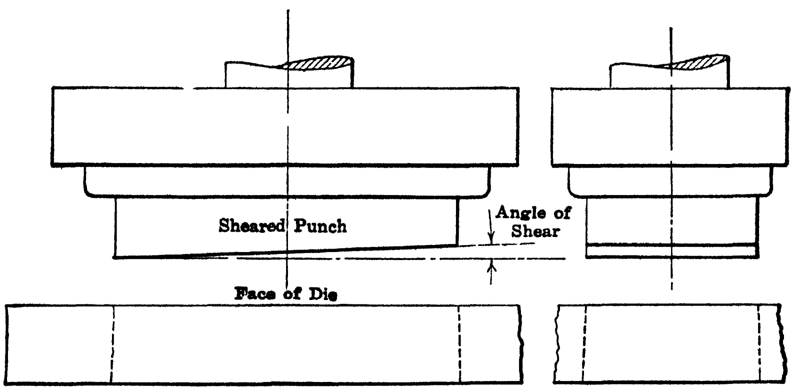


Fig. 53.—A sheared punch.

cut are often finished along the face at an angle as indicated in Fig. 53 to provide the easy cutting action desired. And sometimes for the same purpose the face of the die itself is finished at an angle, and the punch left square on the cutting edge.

Position of Blank Opening in the Die

Reference has been made at an earlier point in this chapter to the location of blanking die openings in relation to the edge of the die—or, it might be better to say, in respect to the longitudinal center line of the die.

The shape and size of the blank are the determining factors by which the location of the die opening is fixed. If the blank is a simple straight piece and not unduly long, it may be located squarely in the die either lengthwise or crosswise according to the width of stock that it may be desired to use or to which arrangement will be most advantageous when the feeding of the stock and the operation of the stock stop are taken into consideration.

It is very often the case that the blank is of irregular form and of such outline that if placed directly lengthwise or crosswise of the die it would

result in a great waste of material, owing to the area of metal that would lie between portions of the blanked openings in the strip as it was fed through. In such cases it is usually possible to locate the die opening at such an angle as to allow projections to overlap one another or to nest in together in such manner as to eliminate to a great extent the waste of material which would otherwise occur. Or, where this is not feasible, the same economy in stock is effected by so arranging the dies and selecting the width of strip material as to permit the stock to be fed through once to allow the blanks to be produced from one side of the strip and then turning it over for a second passage through the dies in which another row of blanks are cut out with their contours interlocking closely with the blanked openings formed in the first passage of the strip through the machine.

Besides the actual economy in material that is brought about by judicious arrangement of the dies relative to the center line or line of stock feed, it is generally possible to keep down to a reasonable number the different widths of strip stock carried in the press room rack, by so laying out new dies as to make use of some standard material always carried on hand. This oftentimes means that the punch and die will be made with their center lines at an angle greater or less with the body of the die so that the work will be blanked out obliquely to the edge of the strip of metal.

Some Examples

It is apparent that even with simple forms of blanks such, for example, as small gears or plain disks, there is an important saving in material by

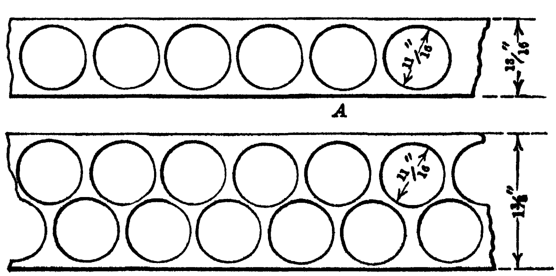


Fig. 54.—Two methods of locating blanks in the stock.

selecting stock of sufficient width to permit two or more rows of blanks to be made from the same strip. Thus, take the illustration in Fig. 54 which shows a strip of stock from which $\frac{11}{16}$-in. disks are blanked in a single row as at *A* and a wider strip for two rows at *B*. By locating the blanks in staggered position the wider strip enables two rows to be produced in a width $\frac{1}{4}$ in. narrower than the combined width of two single strips like the narrow one at *A*. And a still wider strip for three rows of

blanks would be even more effective from the point of view of stock economy.

Some illustrations of blanking dies with the work done in various positions in respect to the center line of the die are shown in the views

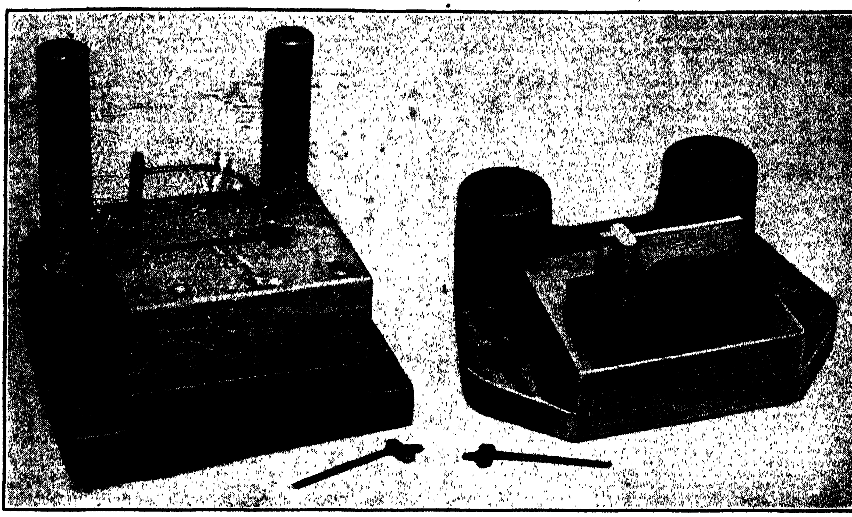


FIG. 55.—Die for a slender blank.

that follow: In Fig. 55, for example, is a set of blanking tools for making a long slender bar, Fig. 56, carrying a clover leaf form of head, the piece measuring about $2\frac{1}{4}$ in. long over all, and the body being only $\frac{3}{32}$ in. wide. The die opening is parallel to the center, and the stock stop is seated in the stripper at an angle to clear the fillister head screw at the side.

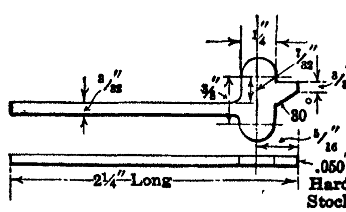


FIG. 56.—The blank.

The blanking die for the piece in Figs. 57 and 58 is made to cut out the work at right angles to the length of stock or 90 degrees around from the position of the die opening in Fig. 55. The dies in Fig. 59 are also made to blank the work, Fig. 60, crosswise of the stock, and here is another good illustration of the advantages in using wider stock than necessary for a single row of blanks and then reversing the strip of metal and running it through for the blanking out of a second row of parts. The construction of this set of blanking tools is shown in Fig. 61.

RELATIVE POSITIONS OF BLANKS

The sketch, Fig. 62, shows the manner in which the blanks in the first row, 1, 1, 1, are spaced and how the second series indicated by numerals,

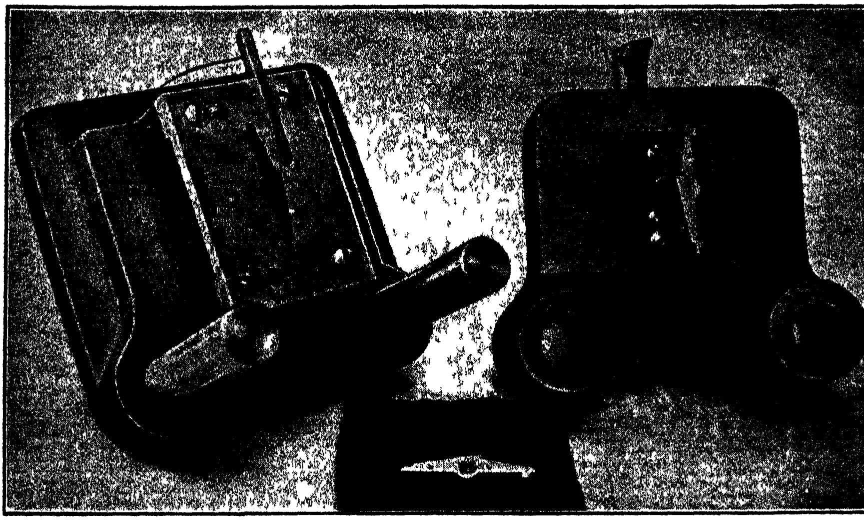


FIG. 57.—A rocker arm blanking die.

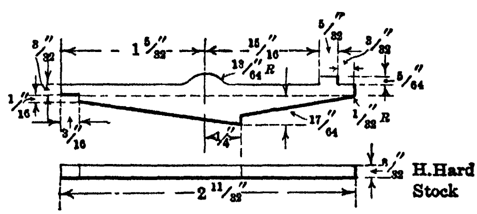


FIG. 58.—Rocker arm blank.

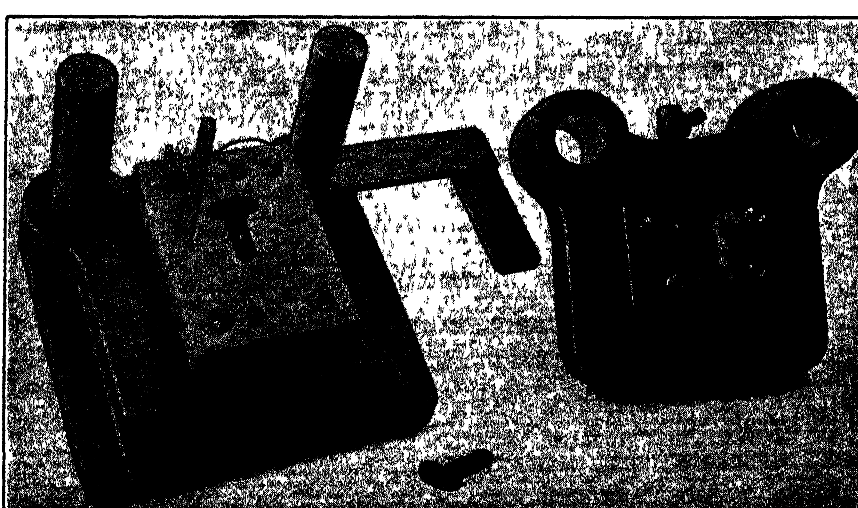


FIG. 59.—Blanking dies for a thick piece.

2, 2, 2, come midway of the openings from the first operation when the stock is fed through on its second round. It may be noticed incidentally that these blanks are from what may be considered quite heavy gage stock for the small over-all dimension.

Here again the stock stop is located in an angular position to enable the contact end to be placed at the required point and the body to clear the screws and dowels in the die.

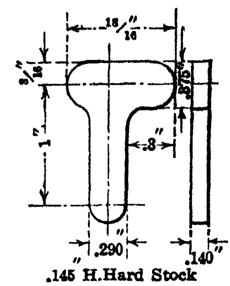


FIG. 60.—A three-lobe blank.

This die has an extension stock guide and support at the right which is especially useful when feeding a strip through that has already been punched out for one row of blanks.

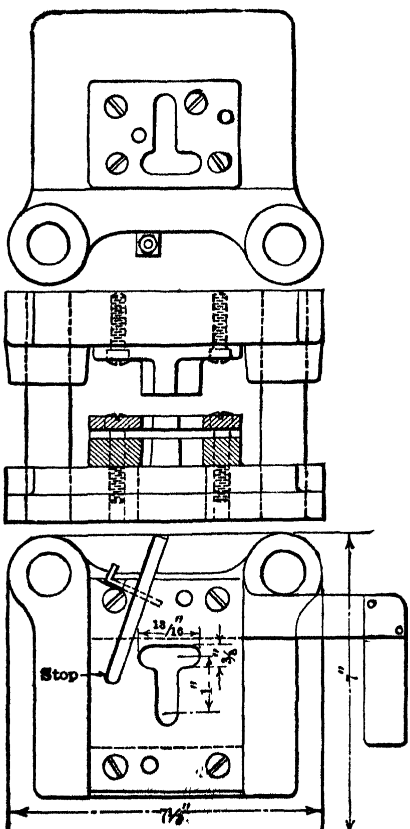


FIG. 61.—Details of dies for blank in FIG. 60.

Another die, with oblique position of opening to blank the work at an angle to the edge of the stock, is seen in Fig. 63, the blank in Fig. 64, and the manner in which the blanks are spaced in Fig. 65. Here is a case where the die and punch are made at an angle to blank the work along closely parallel lines with a minimum of waste between successive blanks. The stock required for blanks thrown around in this way is also much less in width than would otherwise be necessary.

The line drawings, Figs. 66 to 78 inclusive, show further illustrations of strips of stock from which various shapes of blanks of different sizes have been punched. In a number of cases these blanks will be seen to have been made by running the stock through twice, and in these instances the blank positions for the first run are indicated by the numeral 1, and those of the second run are marked 2.

The illustration in Fig. 66 shows the placing of the blanks as produced by the dies, Fig. 55.

In all cases referred to, a few dimensions are given approximately to convey an idea of the general proportions of the work.

These views are presented as of value in suggesting different ways in which such work may be blanked out of the stock to advantage.

A number of the dies thus far illustrated will be recognized as the tools used in blanking various pieces shown in the group in Fig. 39.

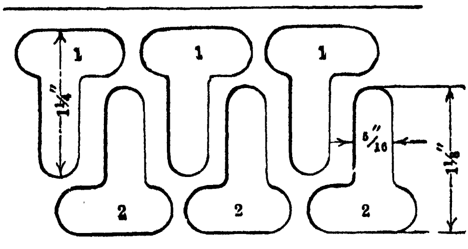


FIG. 62.—Blanking in double run through the press.

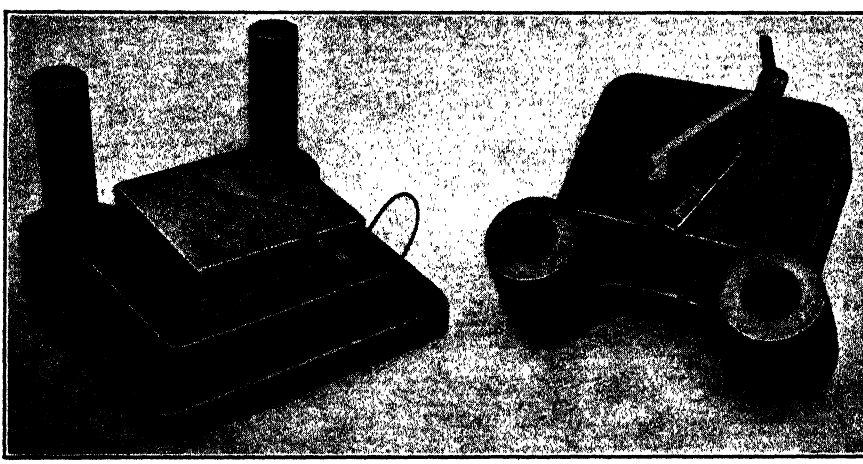


FIG. 63.—Dies made with diagonally placed opening.

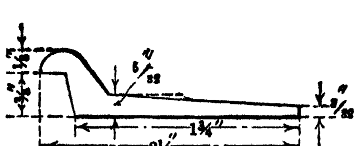


FIG. 64.—Another form of blank.

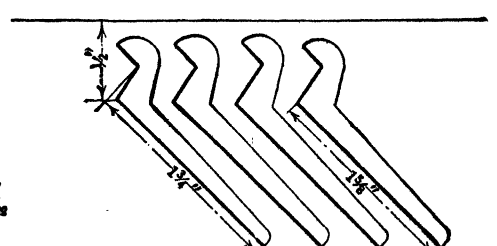


FIG. 65.—Work blank at an angle to edge of stock.

AMOUNT OF STOCK BETWEEN ADJACENT BLANKS

The amount of metal to leave between adjacent blanks in the strip of material is dependent in a measure upon the thickness of the stock and also upon the size and form of the blank. As a rule, a minimum of $\frac{1}{16}$ in.

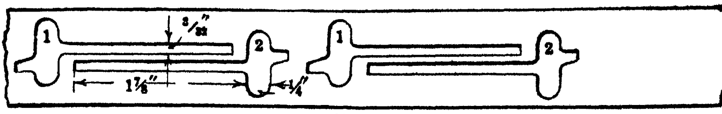


FIG. 66.

FIG. 67

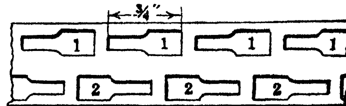


FIG. 68.

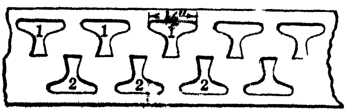


FIG. 69.

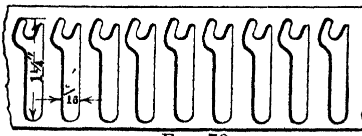


FIG. 70.

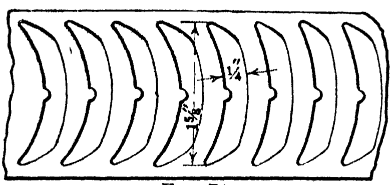


FIG. 71.

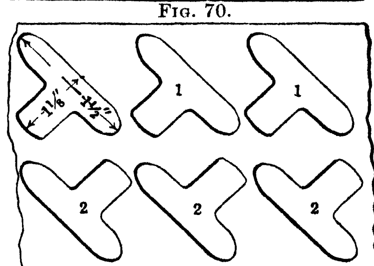


FIG. 72.

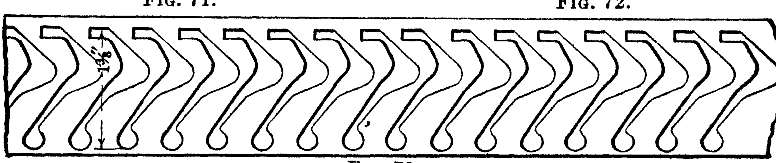


FIG. 73.

FIGS. 66–73.—Various methods of locating blanks in stock.

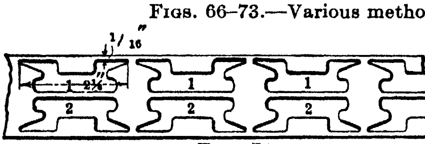


FIG. 74.

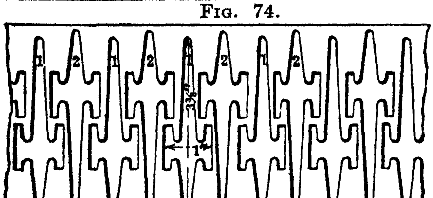


FIG. 75.—(Interlocking) 2 rows.

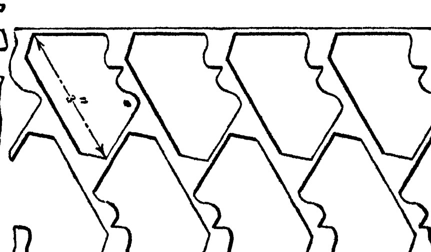


FIG. 76.

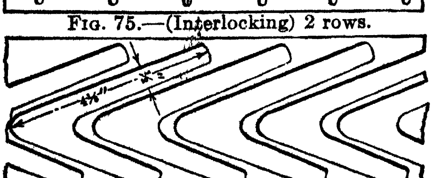


FIG. 77.

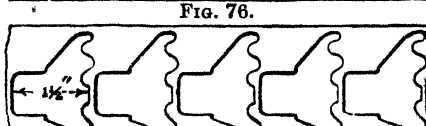


FIG. 78.

FIGS. 74–78.—Methods of locating blanks.

is considered good practice for metal up to $\frac{1}{16}$ in. thick. From that thickness on up to $\frac{1}{8}$ inch it is preferable to leave from $\frac{3}{32}$ to $\frac{1}{8}$ in.

There are cases where thin metal has been blanked with considerably less stock wasted between blanks than the $\frac{1}{16}$ in. referred to. But with many shapes of dies and with certain conditions of cutting edges there is always a possibility that the narrow bar of metal at the ends or sides of the blank may "draw" or pull into the die and result in unsatisfactory operation all the way round.

Moreover, the position and shape of stop used are sometimes factors in fixing the allowance of stock between blanks at a reasonable amount that will not become distorted and unsatisfactory if used as a gage point for feeding against the stop.

Multiple or Gang Tools

Blanking tools, like piercing dies, are often made up two, three, or more in a gang to blank out as many pieces simultaneously.

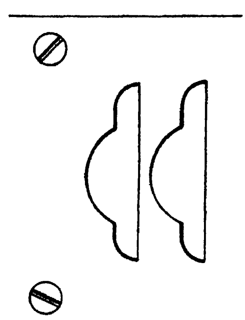


Fig. 79.—Placing of duplex blanks.

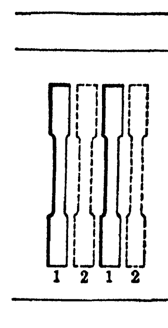


Fig. 80.—Another arrangement of duplex blanks.

A simple blanking set of this character can be made for two pieces as in Fig. 79. An open type of die can be used for such work with provision for producing the two blanks at once. The work is a thin metal blank about 3 in. long. It is made in large quantities, and the duplex type of die is, therefore, an aid to rapid production.

The die can be worked out in the usual fashion; the punches are made separately and are secured to the punch holder by screws and dowels in the manner indicated. The spacing between the two dies is sufficient to leave a strong wall of metal, and there is enough stock left between each pair of openings formed in the strip of metal as fed through so that it is again passed through the dies for blanking out a second lot of shims between the gaps left by the first blanking run.

Another blank made two at a time is in the shape shown in Fig. 80. Here the top of the die or stripper plate is shown with the two openings

spaced double distance apart. This provides a much wider wall of metal between the blanks than would otherwise be possible, and with long slender parts it may be preferable to run the stock twice through the dies, thus blanking out the second run pieces between the scrap openings already formed. In any case the die wall between openings is sufficiently widened by this design to insure ample stability.

Two Other Blanking Dies for Thin Work

Two sets of tools for parts somewhat similar to the work in Fig. 79 are shown in Figs. 81 and 82, these being made for blanking two pieces that

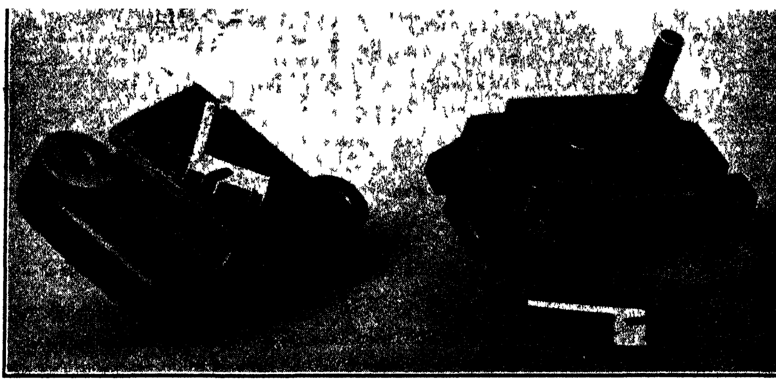


Fig. 81.—Blanking dies with pressure pad and stripper.

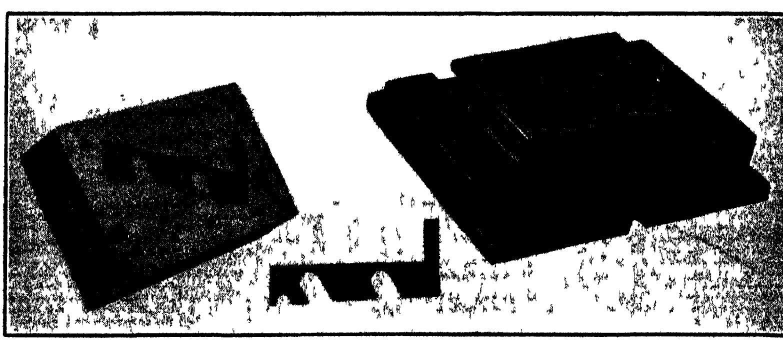


Fig 82—Another blanking die with combined pressure pad and close fitting stripper.

are very much alike. The two dies are, however, directly opposite one another in arrangement. Each has its advantages. Both sets of tools blank out work three or four inches long on a side by $\frac{3}{4}$ to 1 in. wide and only 0.003 or 0.004 in. thick. In some cases the material is brass and in any event the stock is so thin in proportion to its area that special provision is necessary in the tools to produce blanks that will not be wrinkled on the surface or torn and rough along the edges.

Now we have in connection with drawing dies a feature known as a pressure pad whose purpose is the holding of the sheet metal under a definite degree of pressure while the operation of drawing is going on. This is to prevent wrinkling of the work and has the effect of ironing out the sheet metal as it is drawn down into the die from between the pressure pad and the upper face of the die.

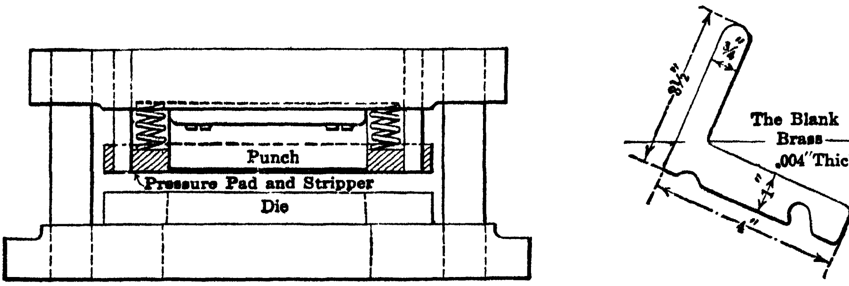


FIG. 83.—Construction of dies in Fig. 81.

COMBINED PAD AND STRIPPER

A similar pressure pad may be employed to advantage in the construction of blanking dies like those in Figs. 81 and 82, only in these instances the pressure pad also combines with it the features of a close-fitting stripper, to clear the scrap from the punch.

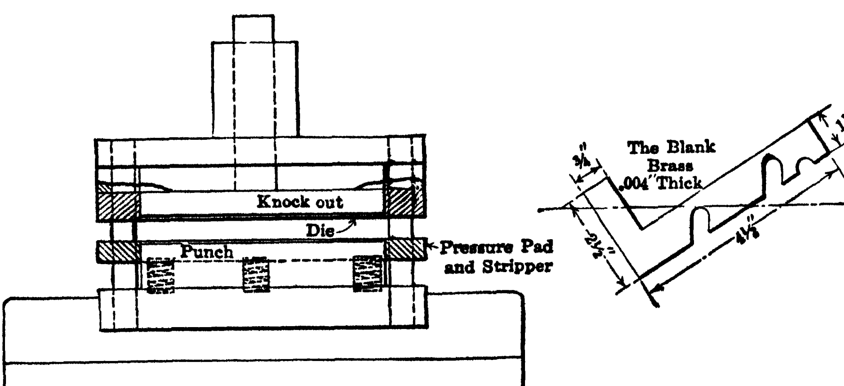


FIG. 84.—Construction of dies in Fig. 82.

Both dies shown are of the sub-pressed or pillar type, and the essential features of each are shown in Figs. 83 and 84, respectively.

In considering first the tools in Figs. 81 and 83, it may be stated that the stripper, instead of being carried by the die in the customary fashion for blanking operations, is here a part of the punch equipment and, mounted in the manner shown, is held down by a series of stiff springs which, when the press slide descends, presses the thin sheet stock firmly

against the upper face of the die and holds it against possibility of movement while the punch cuts out the blank. Upon the up-stroke, the pressure pad acts as a close-fitting stripper, which prevents the stock from lifting with the punch and keeps it well flattened out until the end of the punch is clear of the work.

The Inverted Type of Die

In referring now to the other construction, Figs. 82 and 84, it will be seen that the die is inverted and carried as the upper member of the set while the punch occupies the position below, usually the place of the die.

Here, again, the combined pressure pad and close-fitting stripper are carried by the punch with a set of heavy springs beneath to keep the face of the pad against the lower face of the die when the latter is carried downward by the press slide. As the die cuts out the blank by forcing the stock down over the inverted punch, the pressure pad maintains a firm degree of pressure upon the stock and allows the thin blank to be produced without wrinkling or distortion.

Upon the return stroke of the press slide, the pressure pad acting now as a close-fitting stripper lifts the strip of stock to the top of the punch, and the knock-out carried in the die above ejects the thin blank from the die.

Relative Advantages

There are advantages connected with each arrangement of blanking tools for thin work of the character described. The construction in Figs. 81 and 83 is the more common, for it is somewhat simpler and less expensive to make. It has the disadvantage for very thin stock that the blanks as forced down through the die openings may become clogged and more or less distorted in their passage out of the press. Sometimes, however, this type of die is fitted with an ejector or knock-out that lifts the blank back into the strip of metal, where it is carried out of the press by the advancing movement of the stock through the dies.

With the inverted form of construction shown in Figs. 82 and 84, both stock and blank are kept straightened out at all times, there is no opportunity for the blank to become injured in the dies as it is ejected back on to the strip by the action of the knock-out above, and the edges of both punch and die are kept clear of chips or fine particles of metal by the operation of the stripper and ejector.

Round Blanks, Large and Small

A very appreciable proportion of the blanking jobs that come to the press shop are of generally circular form. Thus for drum and container heads the first operations are the cutting of the round blanks,

which may be accompanied in some cases with an embossing or stamping of the head with essential symbols and lettering.

Many electrical stampings are circular at the outset prior to being notched, and many types of utensils and other sheet metal ware start through the manufacturing process with a circular blanking operation.

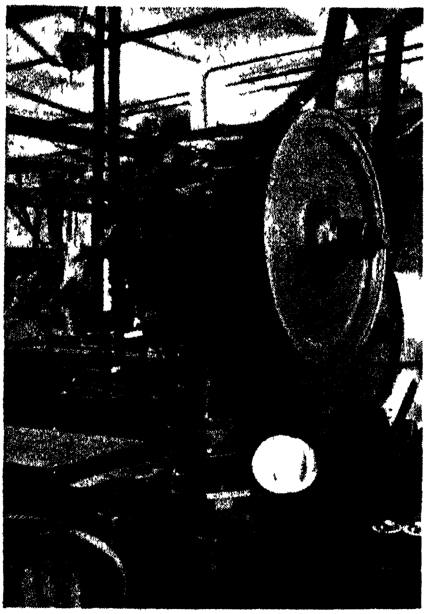


FIG. 85.—Blanking dies for a circular base.

A medium sized blank for a metal base for a portable lamp stand is produced as a preliminary operation in the manner indicated in Fig. 85. The blanks are sheared out approximately to overall size and then run through the dies. The punch carries a stripper ring or shedder so that as it rises from above the die the ring is forced downward by rubber insertions placed between ring and punch head, and thus the outside surplus metal is stripped from the body of the punch.

A large die for a gear, blanked out completely, is shown in Fig. 86. These tools are provided with heavy guide pins and are matched for exact relation between punch and die. The die is open type and carries two gaging points or Vees at opposite sides of the circular form. The punch carries a pilot pin at the center for alining the blank in position for passing into the die.

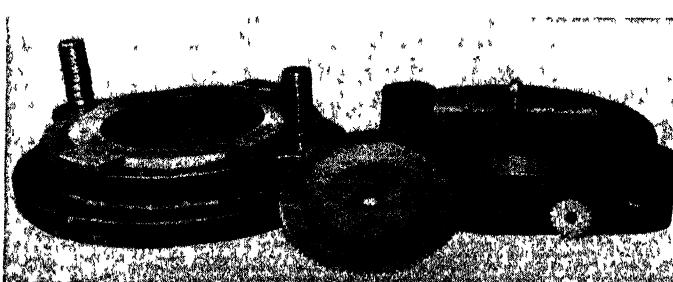


FIG. 86.—A gear-blank die.

MEDIUM AND LARGE BLANKING TOOLS

Press working operations are nowadays extended to include the manufacture of very large work, sometimes measuring up to several feet in length or diameter. The illustrations that follow here are not by any

means of the largest sizes of blanking dies made, but they show at least typical equipment for blanking medium size pieces and parts that for the average shop would be considered fairly big work.

Blanking tools for electric motor disks may be in the form of a cast iron base with a steel cutting ring inserted and secured in the manner plainly shown. This ring is about $\frac{3}{4}$ in. thick and about $1\frac{1}{2}$ in. deep. It is fitted into a counterbored seat in the interior of a cast iron die block, and its upper face is beveled at an acute angle to leave a land at the top of $\frac{1}{8}$ in. or so which is readily ground when the die requires sharpening.

The punch is of similar construction with a steel ring secured to the outer end of a cast disk acting as a holder.

In connection with electrical and similar work there are many parts that have to be manufactured in the form of rings with a large center cut out, and the blank thus removed is utilized for smaller sizes of disks and rings. The outer edge of the big blank has been notched previous to being blanked out inside; and for this second blanking cut, the disk is located or nested on the die by a series of pins spaced about its edge which enter the notches already referred to. The die is made up in the same manner as the one just described, and its cutting ring is provided with the same beveled face and narrow working edge. The blanking punch is formed, as in the case of the first one noted, with a steel ring on a cast center.

Usually dies of large diameter blank their work from a sheet of approximate size instead of from a long strip. Sometimes the sheet is trimmed beforehand to form a convenient size for handling in the press and to enable it to be located against stop pins near the mouth of the die.

In the manufacture of sheet metal ware, such as aluminum utensils, are many examples of large press work seldom seen elsewhere.

An Elliptical Die

A large oval die shown in plan and section in Fig. 87 is for blanking black iron work of Nos. 28, 29, and 30 Birmingham gage, or 0.012 to 0.014 in. thick. The length of the piece is $18\frac{1}{2}$ in. The tools are of the pillar type, and the cutting portions are tool steel rings fixed to cast iron bases, the punch ring being shrunk into place and the die pressed into its seat.

The die is hardened, but the punch is left soft so that when it becomes worn it may be upset slightly and resized. This is a feature sometimes adopted with small tools as well, so that the punch size may be maintained closely to the original size of the die or, if desired, upset to a slightly larger dimension than when first made, in order to compensate for slight increase in the die as the latter becomes enlarged through wear and because of the

tapered interior which increases the die size slightly as the top is ground off by repeated resharpening.

The die shown, however, is straight for a depth of ⅛ in. and relieved only below that point. So it retains its original dimensions until such time as the full eighth inch has been ground down.

The metal to be blanked being very thin for this size of work, the punch is made fairly close fit to the die. The pillars or guide pins are

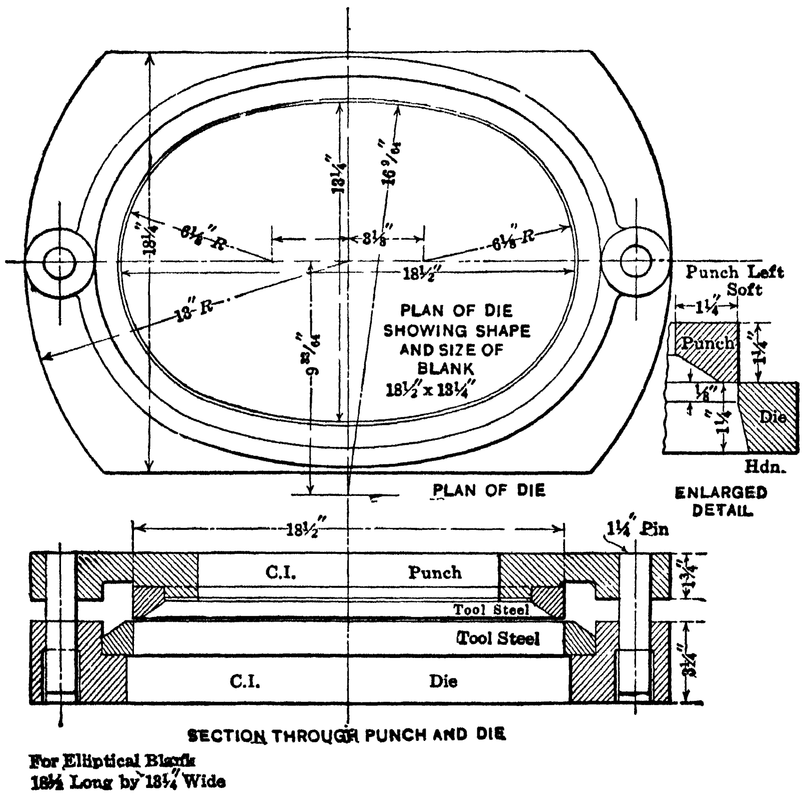


FIG. 87.—Large elliptical dies.

reversed from the usual order, in that they are fixed in the punch holder and slide in the die base holes. This arrangement is necessary on account of the large area of the press ram which prevents the pins from rising above the top of the die.

It will be noticed that the tops of the guide bosses on the die are practically flush with the face of the die. This insures a steadiness of action which is not usually obtainable with big dies of this kind where the bosses referred to are lower than the die face. With the cutting edge of the die and the face of the guides in the same plane the guide pins have a smooth

movement without likelihood of cramping action and consequent shearing and injury of the dies.

In spite of the fact that the punch is left without being hardened, its wear is negligible for a long period. The die proper, although blanking black stock with more or less scale on its surface, will run fully 10,000 blanks before it requires grinding.

Sectional Constructions

The sectional construction for punches and dies permits many advantages to be derived in connection with the making and upkeep of the tools. While this type of construction is a great aid in the making of large dies, it is also extremely useful in the cases of numerous classes of medium sized and fairly small tools, for it enables many awkward forms of dies to be made accurately without serious complications in respect to the tool room methods of handling, where with a solid form of die certain portions of the work would be well-nigh impossible of making up without a very great amount of tedious labor, much of it carried out by hand processes entirely.

The sectional die allows the tool maker to avoid the necessity of working out various odd corners, awkward angles and the like; and when the die is once completed if it later becomes necessary to repair some portion of it, the entire tool is not affected to the extent of requiring replacement. The problem of hardening and tempering is also simplified, and dies of such size and form that they could hardly be hardened satisfactorily at all, if made in a single piece, are under the sectional construction put through preceding processes without difficulty.

The simplest form of a sectional die is produced by dividing the die on the center line with each half secured by fillister head screws and dowels. If the two parts are symmetrical about the center line (as with an elliptical die), it is possible to work them out together so far as the main machine operations are concerned; and in case of distortion in the hardening operation the individual halves admit of convenient correction by grinding and lapping, and the abutting joints may be lapped down if necessary to correct the shorter diameter or minor axis. Also wear may sometimes be compensated for in sectional dies by taking apart and grinding off the face of the joints and reassembling.

Dies with Several Sections

The sectional tools in Figs. 88 and 89 are for blanking a piece that is afterward formed up into a cover for a machine mechanism. There are a number of sharp corners in the die and several delicate, sharply pointed projections The blank is 8 in. long over the outer corners and 2¼ in. across at the widest point.

The die was laid out in the sectional form shown best in Fig. 89 where, as will be noted, the different parts assume a much simpler outline than would at first appear to be possible. One section is a straight, parallel

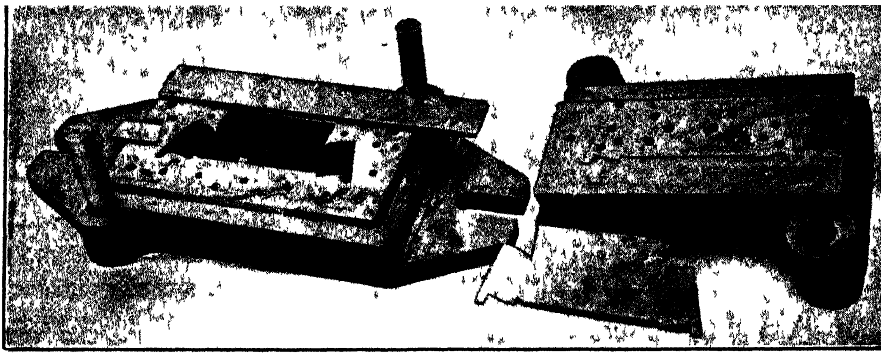


FIG. 88—Another sectional die

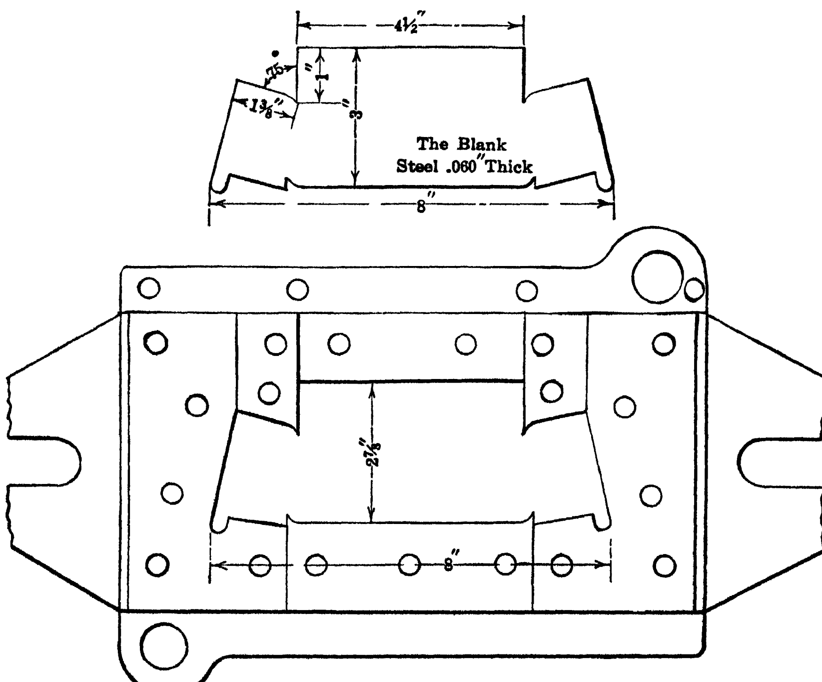


FIG. 89.—Construction of die in Fig. 88.

piece, and three others are almost as simple except for the sloping ends and the curved points in which they terminate.

Here, again, several of the members may be laid out and developed into pairs. The machining and finishing must of course be done with a

knowledge of the change in dimensions that is likely to occur when the parts are hardened, and the corresponding allowance can then be made for correction if necessary before assembling.

Circular, sectional dies are made occasionally as in Fig. 90, where similar die sections are machined and finished and then finished outside to fit into a circular seat in the die shoe. Preparation of uniform sections is sometimes easier where several are required, and replacement is a simpler matter than it is with a solid construction.

The sharp corners in this die are more readily obtained by combining the internal blocks with the circular enclosing ring than where a one-piece design is adopted.

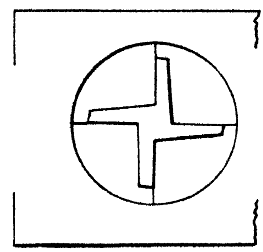


Fig. 90.—Circular sectional die.

The production of an outside ring of the character illustrated can sometimes be facilitated by milling up a length of die steel, that is sufficiently long to allow for the combined length of the four or more enclosed pieces and for the width of the cut-off tool and then severing the length to the required dimension to correspond to the die thickness proper. Of course a little extra material should be allowed for final finishing and grinding off of top and bottom.

The plan selected for sectional dies in general must depend, naturally, on the intricate character of the job. Also, the shape of the different pieces must be fixed by certain conditions, for instance, will the sectional members be weak at any critical point and make it impracticable to use that form of construction. In some cases the one-piece, solid die form may seem to be the only feasible design when heat-treating factors are considered or the total life of the die kept in mind.

With the larger sectional dies (see Fig. 89), where there may be several pieces of peculiar shape, it is customary in tool shops to lay these out so that the main members are parallel to the edge of the die base and then, with this definite start, the remainder of the sections are located accordingly. The pieces are purposely left slightly longer than required and the width oversize a few thousandths to allow for bringing to finish size by grinding and lapping of the abutting edges after hardening and drawing have been attended to.

If handling of the die members has been properly carried out in the hardening and tempering process, very accurate results should be obtained in the finishing and lapping of the contacting surfaces.

The foregoing examples of blanking dies and the data pertaining to them in this chapter have been rather closely restricted to such tools for blanking alone, without taking into consideration the many cases where they are combined or "doubled up" with other dies for piercing and

blanking, blanking and drawing, blanking and forming, and so on. Illustrations of their application in this manner will be presented in chapters that follow.

Big Press Work

Reference was made in the first chapter to the use of big hydraulic presses in modern stamping practice. A 2,500-ton Hydraulic Press Mfg

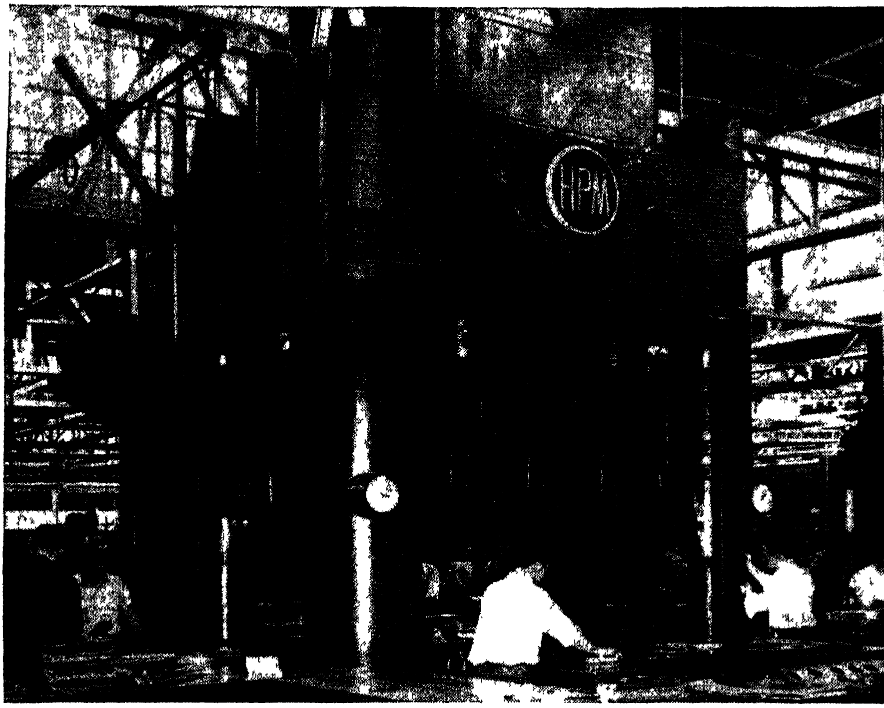


Fig. 91 —Big self-contained HPM hydraulic press stamping aircraft parts by Guerin process

Co.'s unit is illustrated in Fig. 91 as it is employed with the rubber-pad method of producing stampings with a single metal die and a thick resilient pad of rubber or other material on the upper, or movable, platen. Blanks and drawn work are handled in this manner with the minimum of work necessary in building dies of the size and character here required. A typical die is shown in Fig. 92. Details of the process are covered in a later chapter.

Short-run Tools for Small Blanks

While we usually consider blanking dies and other press tools in the light of long runs of work in order to justify the cost of conventional dies, there are many instances where small lots of small stampings can be prod-

uced with the simplest type of inexpensive dies which at least ensure uniformity in the sizes of blanks turned out. While their operation is slow as compared with the usual forms of dies, they are particularly useful in preliminary operations for running off enough blanks for assembly of small lots of work and for testing out the apparatus to which they are applied.

Changes in design of products required are easily effected by the use of such tools. There are no expensive dies involved which have to be scrapped and replaced and there is no great loss in labor time due to alterations which are determined only by actual operation of the parts produced by the dies.

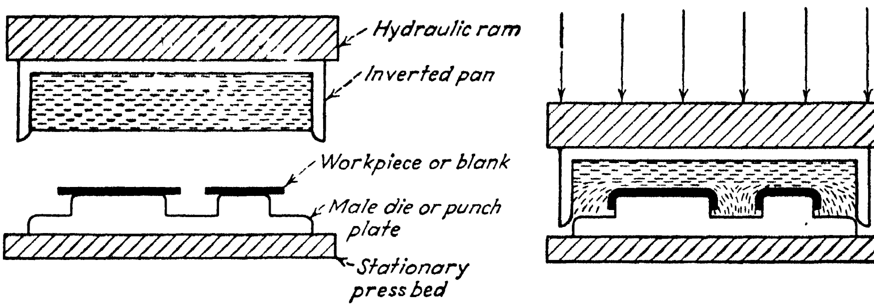


FIG. 92.—Guerin process uses heavy rubber pad with single die for shallow forming. Used in press shown in Fig. 91.

Various lines of expensive complicated equipment have been manufactured with what we know as permanent dies and then some change has been called for necessitating the scrapping of many thousands of dollars worth of conventional press tools. The simple try-out method for any new piece in an assembly may effect large savings during the period when the design of the commercial article may be subject to appreciable change before becoming fixed for real production.

A few short-run dies are included in this chapter as suggesting possible ways of economizing in blank production, either for a fixed very limited run or for testing-out purposes until quantity requirements justify the building of standard rapid production tools.

A Simple Welded Die

The special tools for short-run work shown in Fig. 93 are of a type for producing a few thousand pieces such as those seen at *A*. The various parts of the die as described by Walter Simpson are held together by welding, neither screws nor dowels being used in the construction. To eliminate the cost of a trigger stop the stripper is provided with an opening so that the operator can see how far to advance the strip of stock for each stamping. The rubber block *B* is set in a round hole in the die shoe,

and resting on the rubber and confined in the die is the floater C, composed of four of the stampings welded together.

In operation, as punching takes place, the blank is forced down on the floater, the movement of which compresses the rubber block. As the ram ascends, the pressure on the rubber is released and it springs back and causes the floater to press the blank back into stock tightly enough for it to remain there while the stock is advanced. When the blank reaches past the edge of the die, it drops out of the stock. The plate D

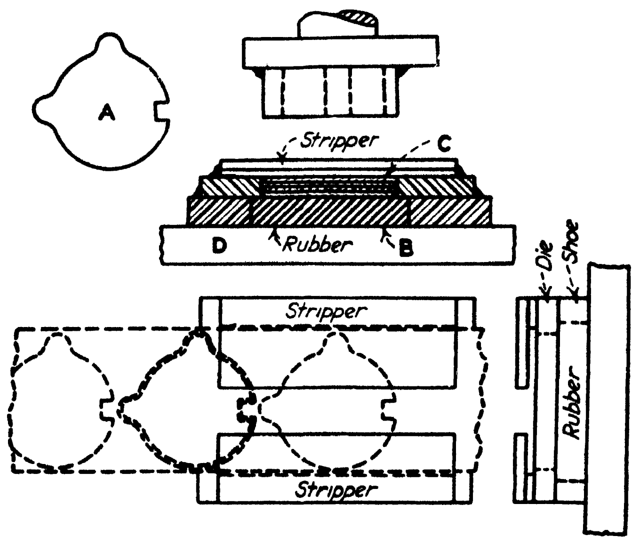


FIG. 93.—Press tools for short-run work.

is used merely to cover the hole in the bolster and it acts as a backing for the rubber.

Low-cost Temporary Dies

While there is no claim that the following method of making inexpensive dies for short runs is novel, it is true that not all shops are familiar with the practice here outlined.

The die proper, Fig. 94, is a piece of cold rolled plate large enough to leave about 2 in. of metal all around the piece to be blanked. Stock $\frac{3}{16}$ in. thick can be used for sheet up to $\frac{1}{32}$ in. and $\frac{1}{4}$-in. plate for $\frac{1}{16}$-in. blanks. Holes drilled at the corners of the pattern allow a saw to be used for the start and for turning the corners. Enough metal is left in sawing for file finishing. A clearance of 2 degrees toward the back is allowed in filing back from the cutting edge. A few $\frac{1}{8}$-in. holes are drilled along two edges as at a, and the die is then heated in a cyanide bath for 30 min. and quenched in water; it is dipped vertically to avoid distortion. Minor changes can be corrected by careful peening with a

hammer and a slightly rounded punch, or a small hand grinder may be used for correcting the die.

The punch *b* is also of cold rolled stock at least $\frac{1}{16}$ in. thicker than the die. Blue vitriol is applied for laying out (as with the die), then the piece is clamped over the die opening and scribed, then it is sawed out and filed until it will just enter the die, and then it is hardened in cyanide.

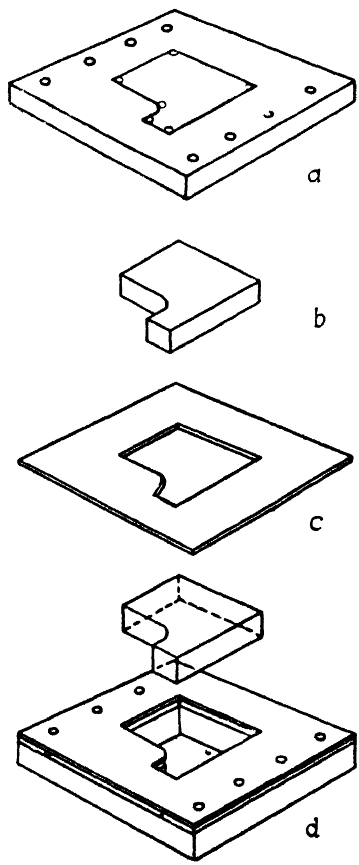


FIG. 94.—Making low-cost dies. (*a*) Layout of die, (*b*) the punch, (*c*) the stripper, and (*d*) punch and die ready for use.

The stripper is a piece of $\frac{1}{16}$-in. steel, large enough to cover the die plate and clamped to the die and the opening is worked out with saw and file until the punch will just slip through the opening. Before removing the stripper it is drilled for the holes to match the holes in the die plate. The stripper is shown at *c* before the holes are drilled. Two spacing strips are located each side of the die opening and these are $\frac{1}{32}$ in. thicker than the stock to be punched. The die, spacers, and stripper are riveted

together, as in the assembly at *d*. The spacing strips are just wide enough to allow the material to slide freely through the die.

Any punch press may be used which has power enough to force the punch through the material. Die shoes with flat faces large enough to support the die are placed in the press and the stroke adjusted to suit. With the strip of material slipped in place under the stripper, the punch is placed in the opening and the press tripped to force the punch through the metal. Both punch and blank will then fall through to the lower shoe and be recovered just the same as if a push broach were being used.

The time required for handling the work is of course very high as compared with regular long-run dies. Harry Swanson in describing this method points out that this kind of die construction is economical only where quantities of less than a few thousand blanks are to be produced, depending on the size of the blank and its relative difficulty of outline.

CHAPTER III

DIES FOR PIERCING AND BLANKING

Piercing operations originally nothing more than the punching of round holes in plates washers, and the like have become extended into every type of sheet metal work and in a very large measure have eliminated drilling operations in ordinary gages of stock as used for a great many classes of metal parts, as in typewriters, business machines, and many other lines of equipment built up largely of stamped elements.

The piercing die combined with blanking and other tools has been developed for about every conceivable type of work coming within the field of the punch press. It is represented in various forms in illustrations here and in other sections of this book.

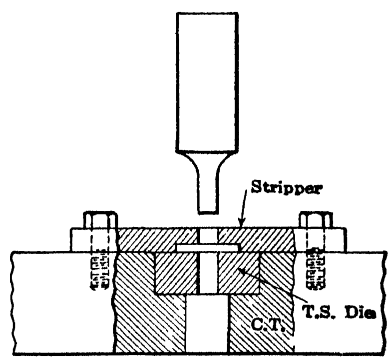


FIG 95.—Section of piercing die.

A simple form of open piercing die is shown by Fig. 95. It consists of a plain die block, a round inserted die, and a stripper and guide for the stock.

The punch is a 1-in. piece of steel turned at the end to the desired diameter for the hole to be pierced. The sectional view, Fig. 95, shows these details.

PUNCH DIES

The simplest form of piercing die and presumably the first form ever made is what is generally known as the "punch die" so commonly used on boiler plate and other sheet metal up to very thick plates preliminary to riveting. Often the dies are inserted in long bed plates, and a row of punches secured in similar types of holders are used for punching a series of holes at once in the edge of a plate.

Dies of this kind are not precision tools in the usual sense of the word, but they are so generally required in certain lines of work that a few particulars regarding their construction may well be included in this chapter.

The punch die proper is usually a round-bodied tool as in Fig. 96 adapted for setting in a circular seat in its block and made with a beveled

top face to aid in the piercing out of the hole upon the descent of the punch. The punch may be either flat ended or with a spiral sheared end which gives a free action and requires less power for the performance of the work. A spiral form of punch is shown at *a*, Fig. 97; the flat end punch by *b*, Fig. 97.

The practice of one of our best-known railroad shop tool rooms in respect to such dies should be of value here as shops of this kind make very wide use of punch dies in their plate departments. It is the practice in the shop referred to to make the dies with $\frac{1}{32}$-in. inside taper or clear-

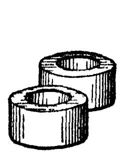


Fig. 96.

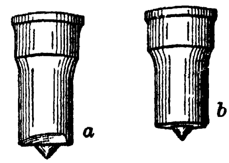


Fig. 97.

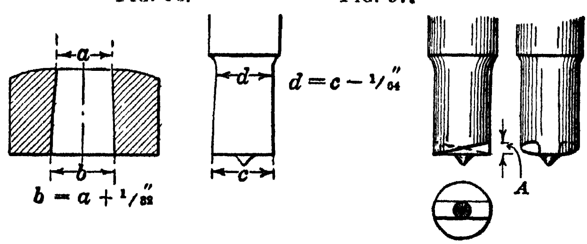


Fig. 98.

Figs. 96–98.—Punch dies for plate work.

ance and to give the punch one-half that amount of taper back from the cutting end, or $\frac{1}{64}$ inch, as in the sketch, Fig. 98. These clearances apply to a 1-inch size of die. For smaller dies, say $\frac{1}{4}$ in., the die has an inside taper of $\frac{1}{64}$ inch, and the punch is cleared back from the end one-half that amount. A proportionate amount of taper is maintained for the intermediate sizes.

The spiral shear on the end of the punch is given at *A* as $\frac{3}{16}$ in. for $1\frac{7}{16}$-in. punches, $\frac{1}{8}$ in. for 1-in. punches, $\frac{3}{32}$ in. for $\frac{3}{4}$-in. punches, and below that the flat end punch is used. The spiral punches are usually employed for plate up to a thickness equal to the diameter of the punch. For plates less than about $\frac{3}{8}$ or $\frac{1}{2}$ in. the punches are left flat.

Life of Tools

There is a considerable amount of clearance between the diameter of punch and die which may be stated to be as follows: For sizes up to $1\frac{1}{2}$ in. allow $\frac{1}{32}$ in. between punch and die size. It is common practice to make the die $\frac{1}{64}$ above and the punch $\frac{1}{64}$ in. below nominal size for the general run of work of this kind. In ordinary practice the die will outlast a number of punches, perhaps ten or more. If starting in at a die thick-

ness of, say, $1\frac{1}{8}$ in., it will be ground down to $\frac{3}{4}$ in. before discarding for the original size of hole, and then it is ground out in the hole for the next larger size of work. Although such dies are used in the most severe service, they are often run for several thousand holes before the tools require resharpening.

Obviously the holes punched are allowed a little more latitude as to size than is permissible with the usual run of press work. To begin with, a punch for a $\frac{1}{4}$-in. rivet will have a diameter about 0.030 larger than the nominal rivet size, and for a 1-in. rivet the punch will be twice that amount larger or 0.060 in. over the nominal diameter of the rivet. The practice of the Pratt & Whitney Company in this respect is covered in the accompanying Table 4 which gives the size of punches as made by that firm for all sizes of rivets from $\frac{3}{16}$ up to 1 in.

TABLE 4.—PUNCH SIZES FOR RIVETS FROM $\frac{3}{16}$ TO 1 IN. DIAMETER

Size of rivet	Size of punch	Size of rivet	Size of punch
Inch	Inch	Inch	Inch
$\frac{3}{16}$	0.210	$\frac{5}{8}$	0.690
$\frac{1}{4}$	0.280	$\frac{11}{16}$	0 740
$\frac{5}{16}$	0.340	$\frac{3}{4}$	0 800
$\frac{3}{8}$	0.410	$\frac{13}{16}$	0 860
$\frac{7}{16}$	0 470	$\frac{7}{8}$	0 940
$\frac{1}{2}$	0.550	$\frac{15}{16}$	1 000
$\frac{9}{16}$	0.620	1	1 060

A DOUBLE PUNCH AND DIE

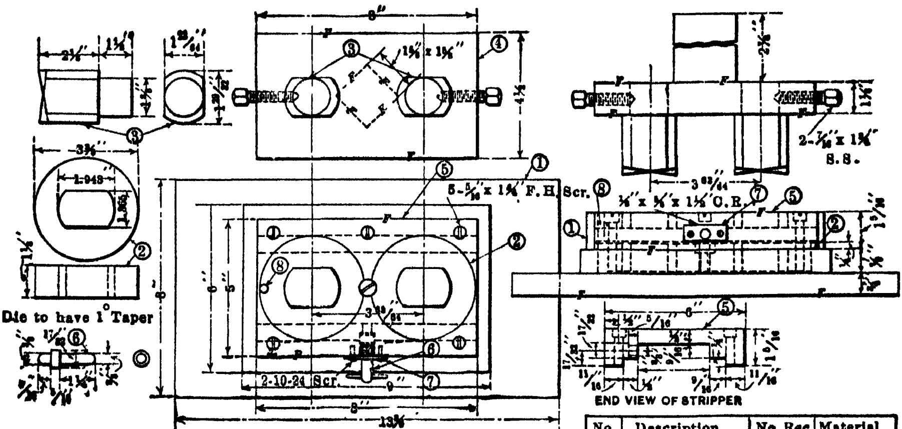
Another form of punch in which the sheared principle is applied is shown in Fig. 99, where the press tools are illustrated for making two rectangular holes in a steel link which is about 8 in. long over-all, the oblong holes pierced in it being 1.94 inch long by 1.365 in. wide. The details of the tools are given to show the manner of inserting separate dies in the block and other features of interest.

The stock pierced with these tools is $\frac{1}{2}$ in. thick. The method of providing shear on the punches from opposite sides will be apparent from the photograph and drawing. There is in the long way of the punch an allowance of $\frac{1}{32}$ in. between the punch and die size, but in the width there is less, or about 0.005 only, for the fit in that direction is more important owing to the parts that enter these link openings, and with the method of shearing the punch there is not so much likelihood of the punches throwing to one side sufficiently to shear the die.

DIES FOR CLOSER WORK

Coming now to the class of piercing dies for the general run of pressroom work where sheet metal of considerably lighter gage is commonly

handled and where a close degree of accuracy is essential, it may be pointed out that the accuracy of results is dependent upon the punch which is made to the size of the hole that is required to be pierced, while the clearance is allowed in the die. It is recommended that for very close results the punch be made 0.001 to 0.002 in. larger than the size of the hole required because the tendency of the work is to hug the punch and when stripped off to close up slightly.



No.	Description	No. Rec.	Material
1	Die Bed	1	M.S.
2	Blanking Die	2	T.S.
3	Blanking Pun.	2	T.S.
4	Punch Holder	1	M.S.
5	Stripper	1	M.S.
6	Guide Pin	1	T.S.
7	Guide Pin Plate	1	C.R.S.
8	Stop Pin	1	T.S.

Fig. 99.—Details of link piercing tools.

The allowances between punch and die for different gages of stock and for various kinds of metal may be taken the same as the clearances between blanking punches and dies as given in Table 2, Chapter II, this clearance depending upon the thickness of the stock and its character as to hardness, etc., and also upon the closeness of the results required. The table has been computed, as already explained, to cover a range of materials and requirements as to accuracy.

Table of Pressures for Piercing

Before entering into details of construction of various types of piercing tools a table of pressures required for different thicknesses and grades of stock may be of interest. Thus Table 5 has been worked out to cover the same gage numbers and materials as are included in Table 3 of shearing pressures in the chapter on Blanking Dies.

TABLE 5.—APPROXIMATE PRESSURES IN POUNDS FOR PUNCHING BRASS AND STEEL; FOR 1-INCH DIAMETER OF HOLE

Gage U. S. standard plate		Shearing strength of brass per sq. in = 35,000 lbs. Shearing strength of steel per sq in. = 50,000 lbs. Shearing strength of high carbon steel per sq. in. = 75,000 lbs.		
No.	Thickness	Brass	Steel	High-carbon steel
28	0.015625	1,718	2,454	3,681
27	0.0171875	1,870	2,790	3,928
26	0.01875	2,067	2,940	4,395
25	0.021875	2,408	3,422	5,168
24	0.025	2,749	3,927	5,890
23	0.028125	3,080	4,396	6,640
22	0.03125	3,440	4,914	7,316
21	0.034375	3,781	5,385	8,024
20	0.0375	4,123	5,890	8,835
19	0.04375	4,816	6,876	10,484
18	0.05	5,498	7,854	11,781
17	0.05625	6,190	8,940	13,236
16	0.0625	6,872	9,817	14,726
15	0.0703125	7,696	10,990	16,520
14	0.078125	8,597	12,246	18,408
13	0.09375	10,335	14,765	22,148
12	0.109375	11,985	17,110	25,721
11	0.125	13,744	19,635	29,452
10	0.140625	15,505	22,135	33,040
9	0.15625	17,150	24,540	36,810
8	0.171875	18,912	27,900	39,280
7	0.1875	20,672	29,400	43,950
6	0.203125	22,321	31,870	47,900
5	0.21875	24,080	34,220	51,680
4	0.234375	25,729	36,700	55,224
3	0.250	27,490	39,270	58,900
2				
1				

Rule: Multiply thickness of stock by length by shearing strength of material.

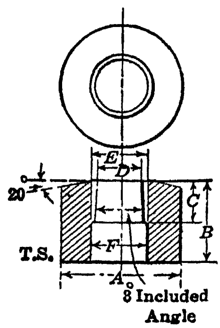
SIMPLE PIERCING TOOLS FOR STRIP METAL

Piercing dies are often required for punching a number of holes in a piece at once, and sometimes the holes run up to a hundred or more, as when piercing fine openings in utensils of one kind or another. Such tools are called perforating dies. Where two or three or a dozen holes or so are punched simultaneously the tools used are generally known as gang dies, particularly when the holes are not very small in diameter. With fine punches, however, they are known as perforating tools.

Table 6 gives dimensions of a series of round or button dies with 3 degrees clearance inside and with 20 degrees bevel at the top. The

outside diameters are dimensioned 0.001 to 0.002 over-size to allow for pressing into place in the die holder.

TABLE 6 —BUTTON DIES



D = diam of hole in die	A	B	C	E	F
$\frac{3}{32}$ to $\frac{3}{16}$	0 626	$\frac{3}{4}$	$\frac{1}{4}$	$D + \frac{1}{8}$	$D + \frac{1}{32}$
$\frac{7}{32}$ to $\frac{5}{16}$	0 8135	$\frac{7}{8}$	$\frac{3}{8}$	$D + \frac{1}{8}$	$D + \frac{1}{32}$
$\frac{11}{32}$ to $\frac{1}{2}$	1 001	1	$\frac{3}{8}$	$D + \frac{1}{8}$	$D + \frac{1}{32}$
$\frac{17}{32}$ to $\frac{11}{16}$	1 252	1	$\frac{1}{2}$	$D + \frac{1}{8}$	$D + \frac{1}{32}$
$\frac{23}{32}$ to $\frac{7}{8}$	1 502	1	$\frac{1}{2}$	$D + \frac{1}{8}$	$D + \frac{1}{32}$

A PERFORATING DIE

An illustration of a perforating die with several hundred punches for piercing the minute holes in the bottom of a thin shell is given in Fig. 100. The punches are all of small drill rod inserted in a holder as in Fig. 101 and

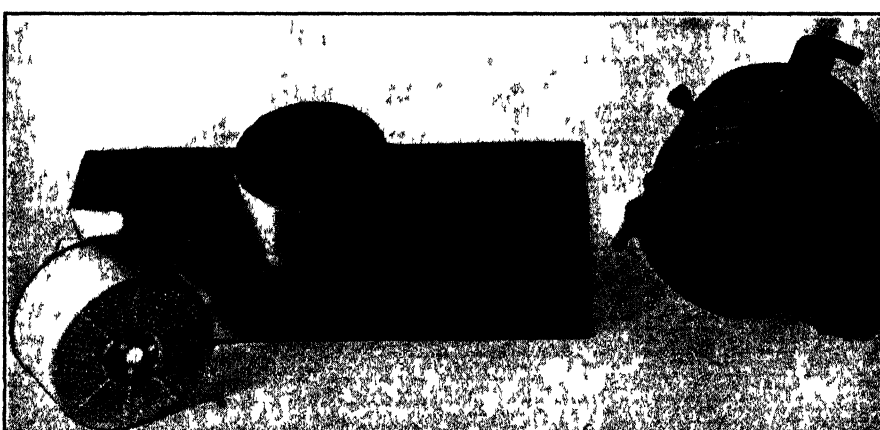


FIG. 100.—Perforating dies.

fitting closely in the stripper plate to give them a support at their cutting ends. The die and stripper plate and holder are all drilled to match by using the plate as a jig. The construction shows an open form of die, though a preferable design would be the sub-pressed type which assures alinement of tools and prevents likelihood of the small punches being broken or the die injured. These tools are shown here, however, as an

illustration of a simple means of perforating a large number of holes at once.

Internal Clearance in Piercing Dies

Piercing and perforating dies are cleared or tapered internally on the same principle as blanking dies, but it is often desirable to give them a greater amount of clearance than the ½ degree on a side, so common with blanking dies, for the reason that the slugs punched out of the stock are apt to clog up in the dies and swage together, forming an obstruction to satisfactory operation and with the smaller sizes of tools leading often to broken punches and sheared dies.

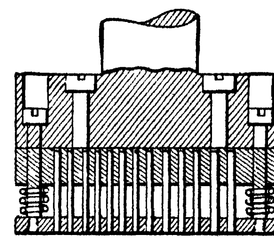


Fig. 101.—Section through perforating dies.

This difficulty has already been referred to in connection with the table of die clearances in the preceding chapter, and Table 1 in that section will therefore be of value as showing the actual clearances in thousandths represented by various side angles in degrees. The table referred to is computed for clearances up to 2½ degrees on a side.

The piercing die is often reamed out from the back with a standard taper pin reamer which gives a clearance of about 1¼ degrees. Then there are special die reamers or broaches so called which given an increased taper equal to 2½ to 3 degrees.

Multiple Tools

The gang dies or multiple dies in Fig. 102 are for piercing four ½-in. holes at once in ⅛-in. steel pieces which have been already formed to length. The method of inserting the punches will be of interest. These are made as at *A* of ¾-in. drill rod, turned down, hardened, and ground, leaving a head at the end which enters a counterbore in the block *B*. The block is of machine steel, accurately bored for center distances and for the size of the punches and closely fitted in a seat planed in the punch holder proper *C*. The heads of the four punches abut against a hardened and ground steel plate *D* which is secured in the punch holder or head to receive the thrust of the punches. Three countersunk head screws hold the thrust plate in place, and two fillister head screws secure the punch block *B*.

The stripper plate *E*, in this case, serves as a pressure pad and is carried by four long fillister head screws. The pressure behind this pad when the punch is down is maintained by a thick rubber pad at *F* which is used by many die makers in preference to a series of heavy springs.

The die *G* is a tool steel block bored accurately, finished by grinding after hardening, and fitted in its seat in the die block. Here it is secured by fillister head screws and dowels.

The tools are of the pillar or sub-pressed order with 1-in. posts or guide pins for preserving alinement. The plan view of the die shows the method of forming the seat for the four-hole die block by making four corner holes in the base for the clearance of the cuts and rounding the corners of die *G* to clear accordingly.

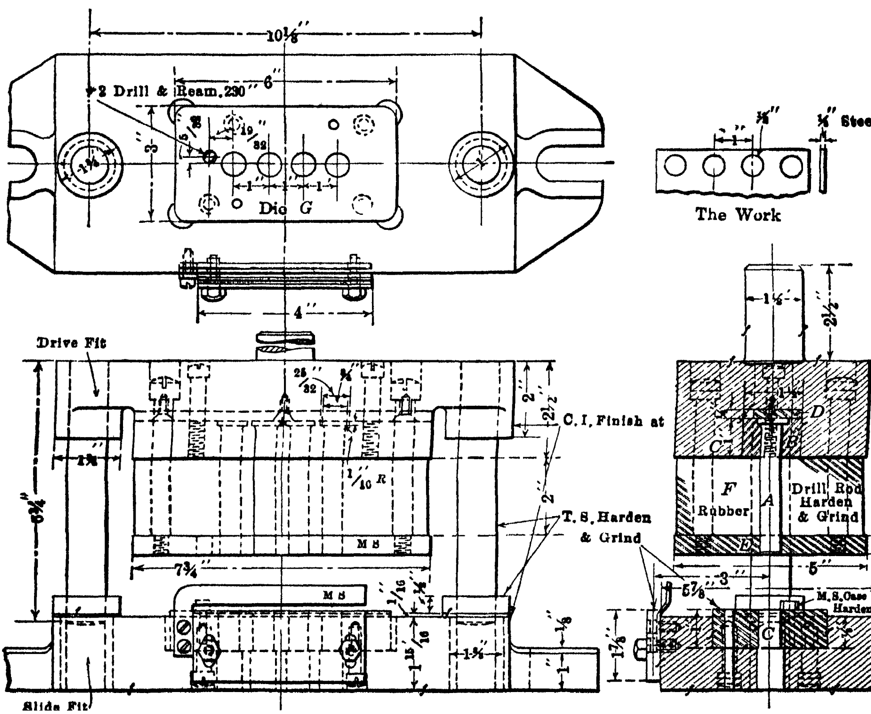


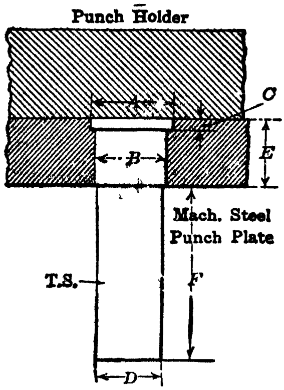
FIG. 102.—Gang-piercing die.

Table 7 covers a series of punches for various sizes of pierced holes. The punch bodies at a point immediately under the head are 0.001 in. large for fitting snugly in the punch plate as indicated. Such punches are readily ground to size and fitted to their places.

BUSHED DIES

With gang dies it is often the practice to make the piercing dies in the form of bushings which can be readily fitted and replaced independently. This is of advantage particularly where there are quite a number of holes to be punched and where the arrangement of the die openings is not along a straight line as they were in the last illustration.

TABLE 7.—PIERCING PUNCHES



Diam. punch D	A	B	C	E	F
In					
0–$\frac{1}{4}$	$\frac{5}{16}$	0 251	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{5}{16}$	$\frac{7}{16}$	0 3135	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{3}{8}$	$\frac{1}{2}$	0 376	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{7}{16}$	$\frac{9}{16}$	0.4385	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{1}{2}$	$\frac{5}{8}$	0 501	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{9}{16}$	$\frac{11}{16}$	0 5635	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{5}{8}$	$\frac{3}{4}$	0 626	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{11}{16}$	$\frac{13}{16}$	0 6885	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{3}{4}$	$\frac{7}{8}$	0 751	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$

In Fig. 103 a set of tools is shown for piercing a series of 40 holes in a circle of 8 in. diameter in a steel disk for electrical apparatus. The pierced disk is shown at the right in the view. The punches are inserted

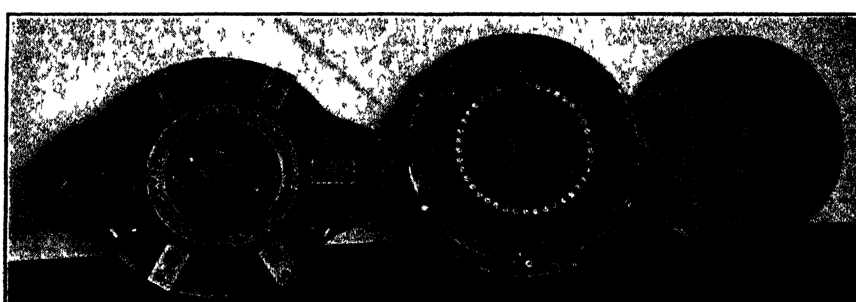


FIG. 103.—Multiple-piercing dies for disks.

in similar fashion to those in Fig. 102, but the stripper plate is backed up by a number of stiff spiral springs instead of by a rubber pad. The die is composed of small bushings hardened and ground and inserted in holes bored in a circle in the die base. These seats for the die bushes are readily located and bored by swinging the work on the dividing head of the milling machine, and the punch holder is similarly treated for the placing of the holes to receive the individual punches.

In addition to the 40 holes in the circle referred to there are six equi-spaced holes punched at the same time in the edge of the disk. The position of the punches and die bushings for this purpose is seen clearly. Also the three stops for forming a locating nest for the round blanks will be noticed in the photograph.

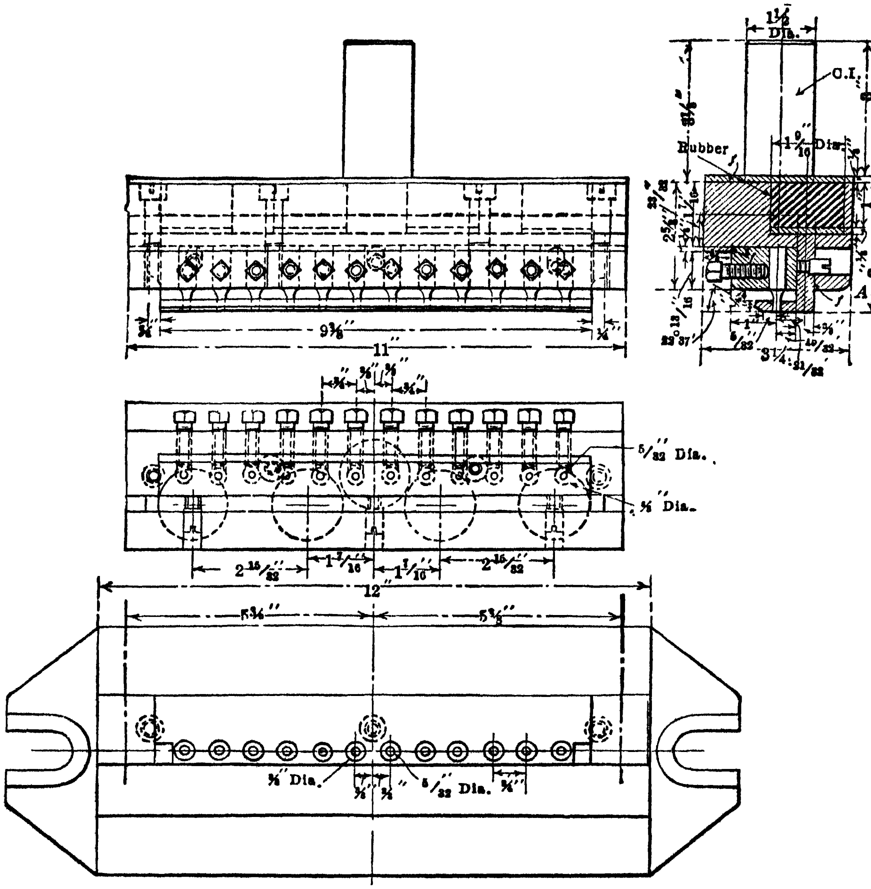


FIG. 104.—Multiple-piercing dies.

Some interesting problems in tool work enter into the making of such dies, locating centers accurately and boring for various members. Each die illustrated in these chapters might be made the basis of a tool room story of importance if space were available for the purpose. However, the details of tool room operations for many typical cases will be covered in special chapters, and an attempt will be made to deal sufficiently with principles and applications so that the handling of general punch and die work will be made clear to the reader not already versed in customary methods.

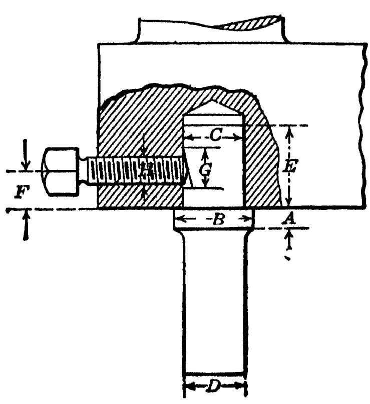
Another Bushed Die

The tools in Fig. 104 illustrate an example of a piercing die for making a long row of holes at one stroke, this design also embodying the principle of a bushed die block which, in this case, receives twelve die bushings set into the block as indicated.

The tools are for punching $\frac{5}{32}$-in. holes $\frac{3}{4}$ in. apart. The dies or bushings are $\frac{3}{8}$ in. deep. The punches are $\frac{3}{8}$-in. drill rod reduced at the end to the diameter specified. They are secured in their holder, a steel block, by set screws. The stripper has an angular form, with the back rising against a set of rubber plugs or springs carried as shown in the punch holder proper. A series of three short screws at *A*, traveling in vertical slots, limit the downward movement of the stripper. The dotted circles in the plan view of the punch bring out the method of positioning the rubber sections to give ample pressure to back up the stripper.

The punches in Table 8 are useful where they are close to the edge of the punch holder and therefore reached by set screws. The sizes given range from $\frac{1}{4}$ to 2 in., and they are suited for blanking as well as piercing operations.

Table 8.—Piercing Punches Held by Set Screws



D = diam.	A	B	C	E	F	G	H
Ins.							
$\frac{1}{4}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{3}{8}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{1}{2}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{9}{16}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{5}{8}$	$\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{3}{4}$	$\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{7}{8}$	$\frac{1}{8}$	1	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
1	$\frac{1}{8}$	1	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
$1\frac{1}{8}$	$\frac{1}{8}$	$1\frac{1}{8}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
$1\frac{1}{4}$	$\frac{1}{8}$	$1\frac{1}{4}$	1	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{1}{2}$
$1\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{2}$	1	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{1}{2}$
$1\frac{3}{4}$	$\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{5}{8}$
2	$\frac{1}{8}$	2	$1\frac{3}{8}$	$1\frac{7}{8}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{5}{8}$

Second Operation Piercing Tools

There are numerous instances where work previously blanked goes to the piercing dies to have holes of one form or another punched through in a second operation. Several instances of the sort have been included in the examples of work handled in the dies illustrated in this chapter, these being in the main fairly large-sized pieces.

In Fig. 105 a pair of dies are shown for piercing two holes in the ends of the rocker-shaped lever seen in the foreground. The round hole is less

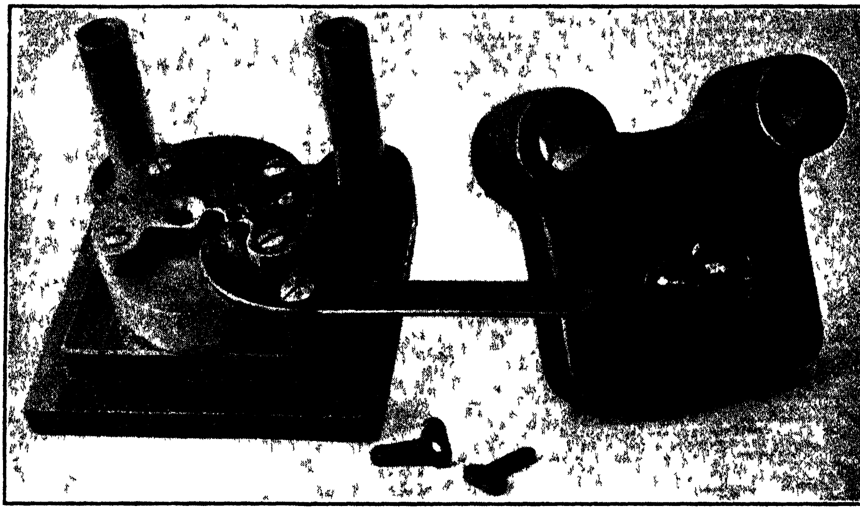


FIG. 105 —Piercing tools for blank with two holes.

than $\frac{1}{8}$-in diameter; the oblong hole in the body is $\frac{3}{16}$ by $\frac{5}{16}$ in. The piece is 0.140 in. thick and of steel.

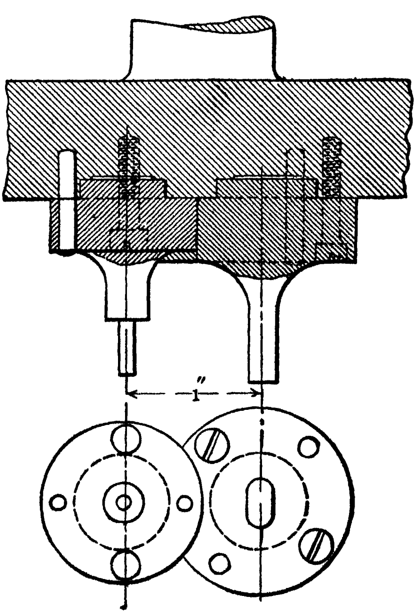


FIG. 106 —Double-piercing punches.

The method of holding is to slip the work under the stripper and hold it against the interior seat or open nest by means of the handle in front. The punches, as seen in Fig. 106, are machined upon large pieces of tool steel which form substantial bases, and these are secured to the head by two fillister screws and two dowels each. The larger punch circle is cut out at the back to admit the edge of the other flange to allow the right center distance to be secured. The form of the punches is very rigid, and there is little probability of their springing. This design of punch with solid back, which is turned down to give the punch size, is a commendable one, for it provides a rigid seat and a punch that cannot spring as would be the case were it straight all the way back and inserted simply in the holder forming the head of the sub-pressed dies.

The dies are round and of the proper size inserted in the base block. The stripper plate is countersunk around the holes to allow the short, stiff punches to enter and clear at the point of enlargement.

Blanking and Piercing Dies

After all, the most commonly found cases of piercing operations are where they are in conjunction with blanking, the required holes being first

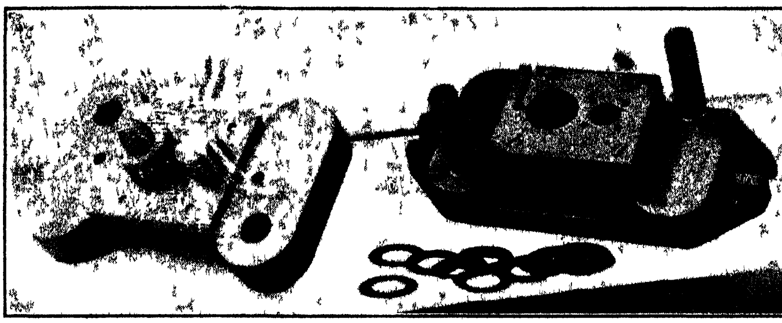


Fig. 107.—Progressive piercing and blanking dies for a special washer.

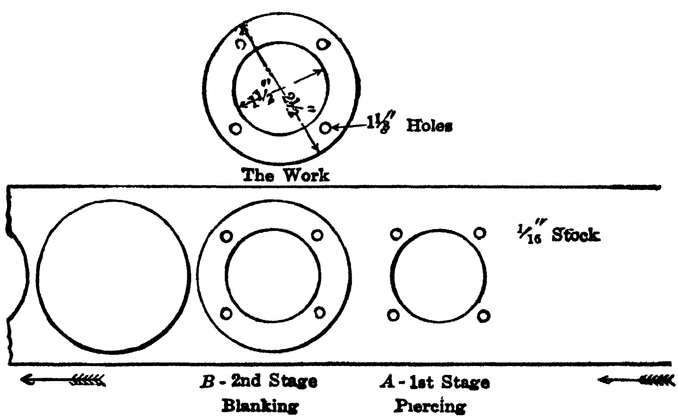
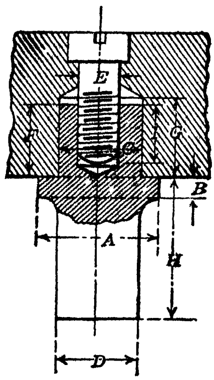


Fig 108 —Successive steps in making the washer

pierced in the strip of stock, and the next stroke of the press causing the piece to be blanked out. A simple but good illustration of the principle is presented in Fig. 107 which shows a round washer with four small holes pierced at quarters around the circle.

The piercing tools are located at the right hand or the end where the stock enters. The center hole is here punched out, and the four smaller holes pierced as at *A*, Fig. 108. The next advance of the stock allows the strip of metal to be located correctly by the pilot on the end of the blanking punch so that as that punch passes through the stock the washer is blanked out concentrically as at *B*, Fig. 108.

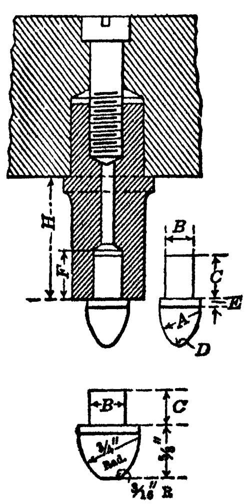
TABLE 9.—PUNCHES HELD BY SCREW TAPPED IN FROM THE TOP



D = diam. of punch	A	B	C	E	F	G	H	I
Ins.								
$\frac{1}{4}$	$\frac{5}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{3}{8}$	$\frac{5}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{9}{16}$	$\frac{3}{4}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{5}{8}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{3}{4}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$\frac{7}{8}$	1	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
1	$1\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{5}{32}$	1	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$1\frac{1}{2}$	$1\frac{5}{8}$	$\frac{5}{32}$	1	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$1\frac{3}{4}$	$1\frac{7}{8}$	$\frac{5}{32}$	$1\frac{1}{4}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
2	$2\frac{3}{16}$	$\frac{5}{32}$	$1\frac{3}{8}$	$\frac{3}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$

A substantial type of punch for either piercing or blanking and one that is secured in practically the same manner as the two larger ones in Fig. 107 is covered in various sizes by Table 9. This construction provides for the securing of the punch in its holder by means of a fillister head screw tapped in from the top as indicated. This method is the one used with many such punches as are illustrated in Fig. 107.

TABLE 10.—PILOTS FOR PROGRESSIVE BLANKING PUNCHES



A	B	C	D	E	F	H
Ins.						
$\frac{3}{16}$	$\frac{1}{8}$	$\frac{5}{13}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{7}{16}$	$1\frac{3}{16}$
$\frac{1}{4}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{9}{16}$	$1\frac{3}{16}$
$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{5}{8}$	$1\frac{3}{16}$
$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{5}{8}$	$1\frac{3}{16}$
$\frac{7}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{32}$	$\frac{1}{16}$	$\frac{5}{8}$	$1\frac{3}{16}$
$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{5}{8}$	$1\frac{3}{16}$
$\frac{5}{8}$	$\frac{5}{16}$	$\frac{9}{16}$	$\frac{5}{32}$	$\frac{1}{16}$	$\frac{11}{16}$	$1\frac{3}{16}$
$\frac{11}{16}$	$\frac{5}{16}$	$\frac{9}{16}$	Flat end	$\frac{1}{16}$	$\frac{11}{16}$	$1\frac{3}{16}$
$\frac{3}{4}$	$\frac{3}{8}$	$\frac{5}{8}$	Flat end	$\frac{1}{16}$	$\frac{3}{4}$	$1\frac{3}{16}$
$\frac{7}{8}$	$\frac{3}{8}$	$\frac{5}{8}$	Flat end	$\frac{1}{16}$	$\frac{3}{4}$	$1\frac{3}{16}$
1	$\frac{7}{16}$	$\frac{11}{16}$	Flat end	$\frac{1}{16}$	$\frac{13}{16}$	$1\frac{3}{16}$
$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Flat end	$\frac{1}{16}$	$\frac{7}{8}$	$1\frac{3}{16}$

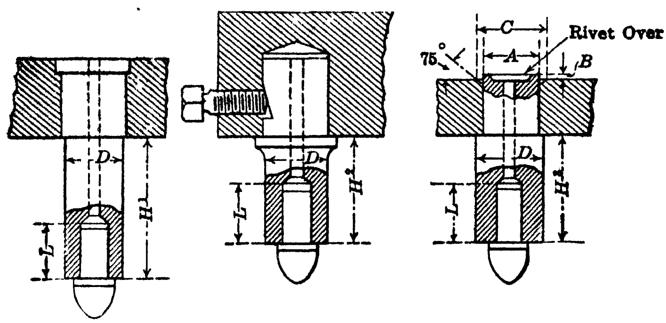
Pilots

The pilot is inserted in the blanking punch and is made to a long radius, equal at least to the diameter of the pilot body. This question of pilots is of interest as they are so extensively used in connection with progressive dies. Table 10 herewith is laid out to cover pilot dimensions for the type of punch which is held by a fillister head screw tapped in from the top of the punch holder. The same dimensions apply also to pilots for the other

TABLE 11.—PROGRESSIVE BLANKING PUNCHES WITH PILOTS

For Pilot Dimensions Refer to Table 10

Make L for All Punches Equal to Pilot Shank + $\frac{1}{8}$ In. (See Table 10 for Pilots)



D = diam.	H^1	H^2	H^3	A	B	C
Ins.						
$\frac{1}{4}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{5}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{3}{8}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{7}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{1}{2}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{9}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{5}{8}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{11}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{3}{4}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{7}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{9}{16}$	$\frac{1}{16}$	$\frac{11}{16}$
1	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{1}{16}$	$\frac{3}{4}$
$1\frac{1}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{3}{4}$	$\frac{1}{16}$	$\frac{7}{8}$
$1\frac{1}{4}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{7}{8}$	$\frac{1}{16}$	1
$1\frac{1}{2}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$\frac{3}{32}$	$1\frac{5}{16}$
$1\frac{5}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$\frac{3}{32}$	$1\frac{7}{16}$
$1\frac{3}{4}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$\frac{3}{32}$	$1\frac{7}{16}$
$1\frac{7}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$\frac{3}{32}$	$1\frac{1}{2}$
2	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{8}$	$\frac{3}{32}$	$1\frac{9}{16}$
$2\frac{1}{8}$	....	....	$1\frac{3}{16}$	$1\frac{3}{8}$	$\frac{3}{32}$	$1\frac{9}{16}$
$2\frac{3}{8}$	....	....	$1\frac{3}{16}$	$1\frac{1}{2}$	$\frac{3}{32}$	$1\frac{11}{16}$
$2\frac{5}{8}$	....	....	$1\frac{3}{16}$	$1\frac{3}{4}$	$\frac{3}{32}$	$1\frac{11}{16}$
$2\frac{7}{8}$	....	....	$1\frac{3}{16}$	2	$\frac{3}{32}$	$2\frac{3}{16}$

classes of punches whose proportions are given in Tables 7, 8, and 11, and in all cases the pilots should be ground or otherwise finished on the stem or shank to a press fit in the ends of the blanking punches.

Ordinarily the pilots can be made of drill rod. In the smaller sizes, as indicated in the tables, the point of the pilot is rounded to a definite radius given in Column *D*, Table 10. For larger sizes of pilots the bottom end is flat, reducing the length accordingly, and the corners are rounded to a radius of $\frac{3}{16}$ in. These proportions are varied where necessary, but for a wide range of work they have proved satisfactory.

Progressive Die Section

The sectional view, Fig. 109, represents one standard form of construction for progressive dies with the tools shown on the vertical center

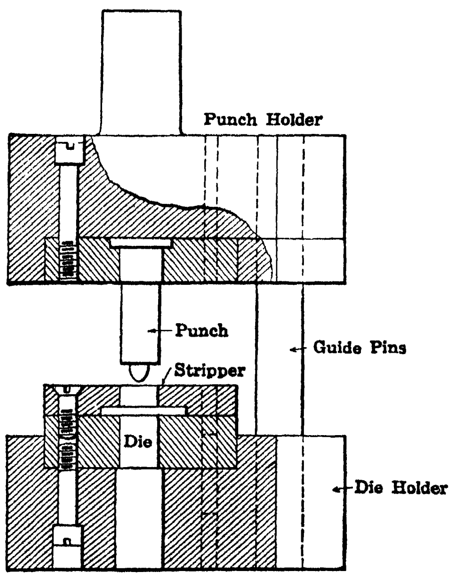


Fig. 109.—Construction for progressive dies.

line of the blanking punch. The die is here seen secured in its holder or base by fillister head screws and dowels which are independent of those used for attaching the stripper to the die. The screws for the latter purpose are short, countersunk head screws which may be removed to permit the stripper to be taken off and the die to be examined or ground without disturbing it in its holder.

This is an advantage over the alternative construction commonly used, where one set of screws and dowels are employed for both stripper and die.

Another Example

The piercing and blanking tools in Figs. 110 and 111 punch two small rectangular holes in the german silver stock and blank out the piece to the dimensions given in the latter drawing. These engravings show clearly the method of making the main punch from a solid block and inserting in its body the two piercing punches, which are formed with round bodies for that purpose.

The punch rests squarely upon its base which has ample area to give it security, and one fillister head screw and two dowels fasten it in place.

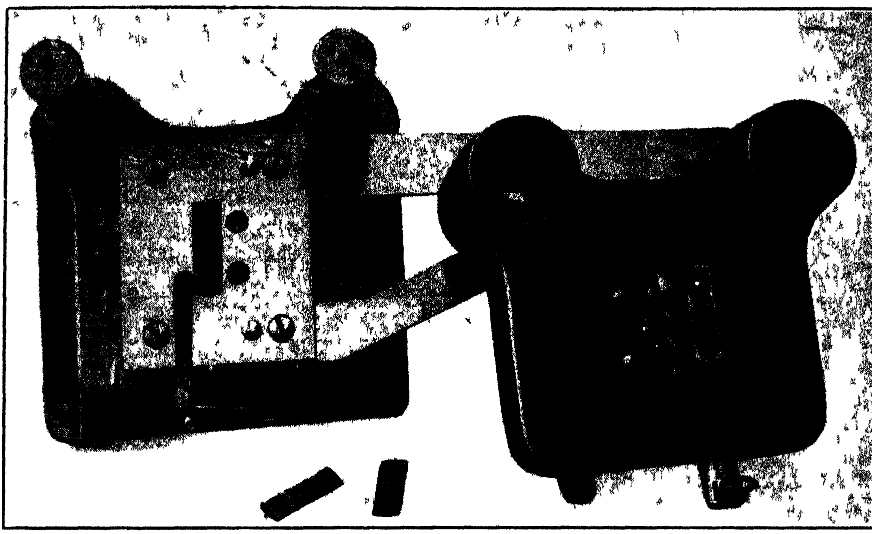


Fig 110.—Progressive tools for piercing and blanking a rectangular part

The blanking portion of the punch is machined up mainly by milling, and the large fillets in all corners give a rigidity that is most desirable in tools of this character. The two holes for the piercing punches are located accurately and bored through for the enlarged shanks, and the piercing portions are left purposely short to provide further stiffness.

The piercing dies are of the button type inserted in seats in the main die in which they are pressed snugly. A stop of the trigger type is carried in the stripper as represented, and a finger, spring-actuated and adapted to press inward and hold the stock against the guide, is included at the side of the stop as seen in the sketch.

It will be noticed that the piercing punches are shorter than the blanking punch by a sufficient amount to allow the latter punch to strike through the stock before the piercing punches enter the work. This permits the blanking punch to locate the work properly by means of its

pilots and also prevents any undue stress being imparted to the piercing punches by the action of the larger blanking punch upon striking the stock.

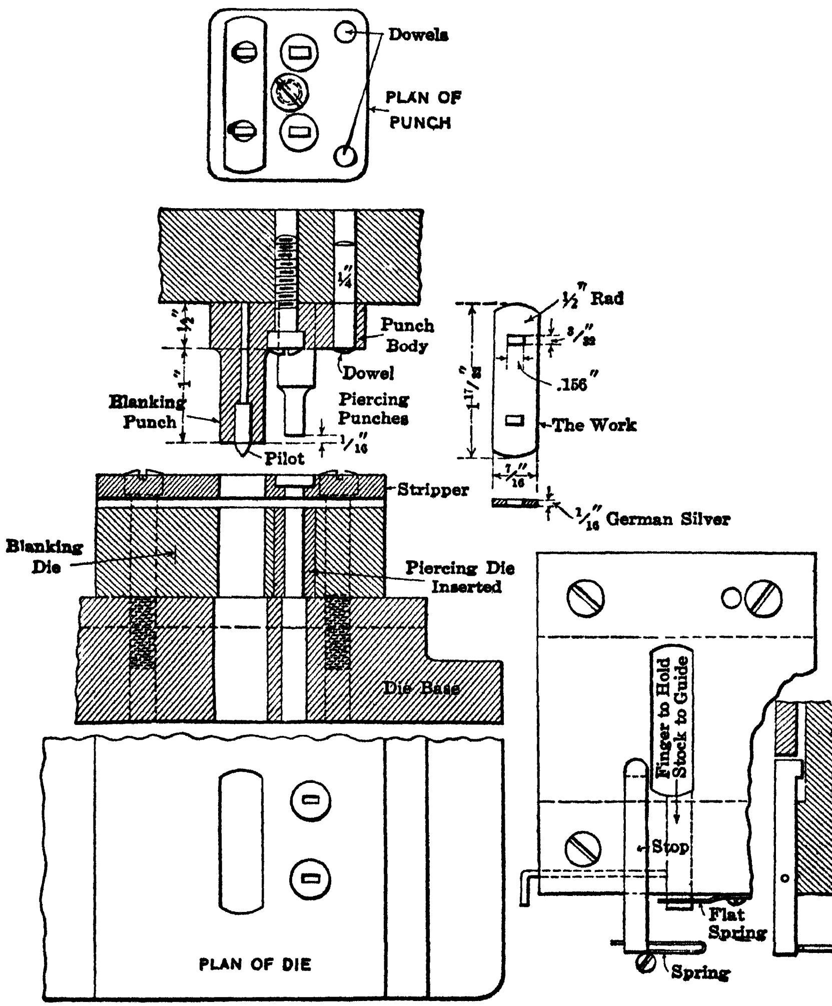


FIG. 111.—Details of tools in Fig. 110.

TOOLS FOR A TOOTHED PIECE

A set of tools which combine in a different manner certain of the features of some of the dies already described are illustrated by Fig. 112. These produce the piece, Fig. 113, from $\frac{1}{16}$-in. steel stock.

The large piercing punch for the center of the gear disk is made with an enlarged base, as in previously shown constructions, and the four small

piercing punches are inserted therein, the group of five punches then being secured by two screws and two dowels as plainly seen. The blanking

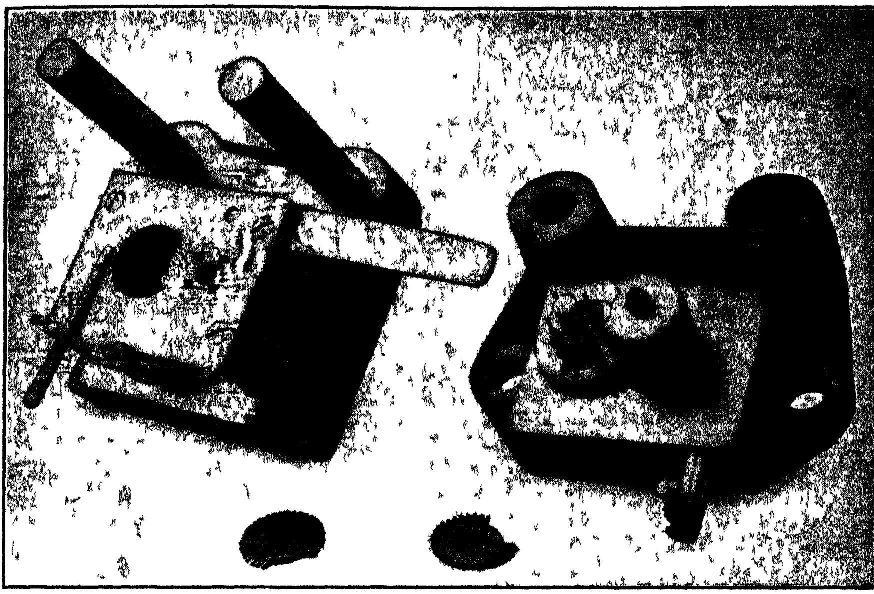
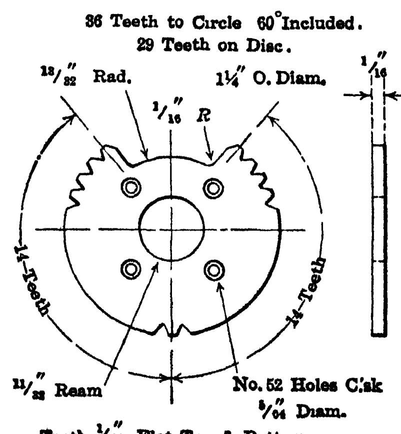


FIG 112 —Progressive dies for an interrupted gear wheel

punch is turned with a locating hub and secured by screw and dowels from the top of the punch holder. The punch teeth are milled by special cutters, and similar cutters are used for making broaches for working out the teeth in the die which is finished out in the teeth by machine filing, broaching, hand filing, and lapping.

With the teeth worked out somewhere near to size, the broach is forced in $\frac{1}{64}$ in. or so, under a hand press; then hand filing is resorted to to remove the stock to the outline set in by the broach, after which the broach is again applied and forced down a little farther, the process being repeated, and filing being done to the point broached until the broach has been passed down through the die.



Drum Reverse Lock Disc.
1/16" x 1⅜" H.Hard Stock.
FIG. 113.—Detail of gear wheel.

The details of operations on dies of this class with accurate tooth forms to produce will be taken up at length in another section of this book. The

dies just referred to are shown at this point to illustrate an interesting form of progressive tool which is put together in substantial fashion.

Other Progressive Types of Piercing Tools

The dies in Fig. 114 are for piercing and blanking progressively the small pointer blank shown in the insert and also in the sketch, Fig. 115.

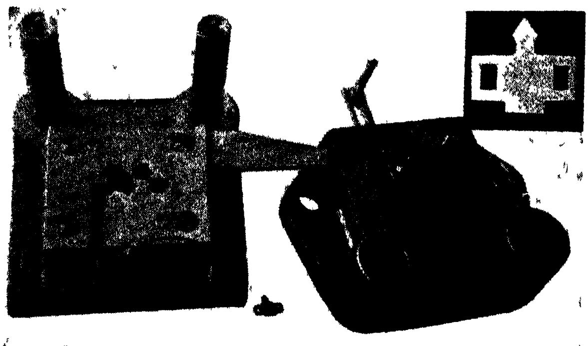


Fig. 114.—Piercing and blanking tools for indicator.

The blank is located at an angle to the axial line of the dies. The two pierced holes are rectangular in form, and their punches are formed on round shanks which pass through round holes in the stripper as shown in Fig. 116.

A trigger stop is fitted to the die shoe, and this is set to stop the strip of metal by dropping into the lower of the two pierced holes. The punch for the blank is fitted with two pilot pins which enter the narrow slots

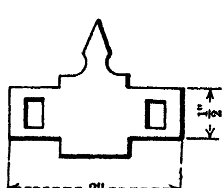


Fig. 115.—Blank made in dies in Fig. 114.

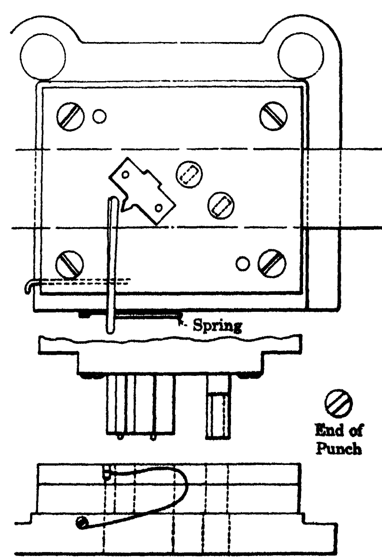


Fig. 116.—Drawing of tools shown in Fig. 114

pierced in the stock and locate the work for the correct position for blanking. The trigger stop is actuated by the adjustable pin on the punch head against the looped spring under the front end of the trigger.

Slotting and Blanking

The thin narrow blanks in Fig. 117 and at the right in Fig. 118 are pierced or slotted crosswise, then formed to hollow shape, and then blanked. Finger stops like those in Fig. 119 set the strip of stock at

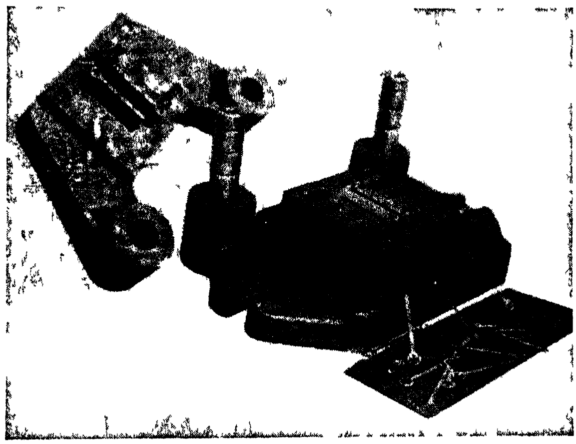


Fig 117.—Blanking and forming dies

the outset. Punch A^1, Fig. 118, pierces the first slot in the head; then punch A^2 pierces the cross slot, thus leaving four pointed leaves. Punch A^3 forms down the bowl-shape depression, pushing the pointed leaves into a convex position. Punch A^4 blanks out the piece.

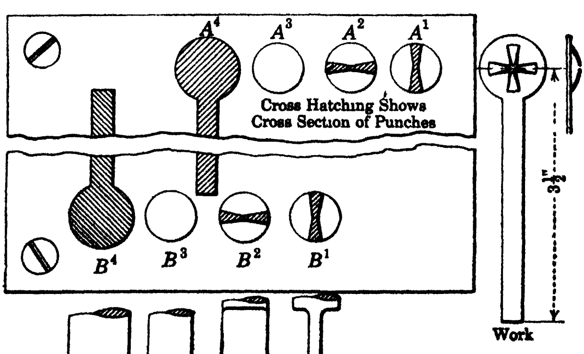


Fig 118.—Arrangement of punches for dies in Fig. 117.

After the stock has advanced to third position the opposite row of punches at the front of the die (B^1, B^2, B^3, B^4), duplicate the series of operations described on blanks reversed in position in the strip of stock (see Fig. 119). Two pieces are then blanked out complete at each stroke of the press.

A Sheared Die

The die in Fig. 120 is for producing a flat blank from rather heavy stock; and to ease the action on the tools and work and produce a smoother, better job, the shearing principle has been adopted for the die face. The progressive feature for the piercing and blanking in sequence is apparent, and the arrangement of piercing punch and the pilot in the blanking punch is likewise clear. The blanking punch is made with a wide base to seat in the crosswise channel in the holder, and the screws are run in from the rear.

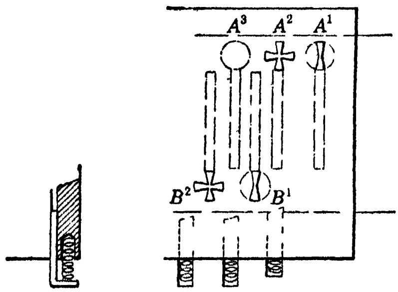


Fig. 119.—Stock stops for dies in Fig 117

The shear on the die face is in the form of two concave surfaces covering about two-thirds the length of the die. The stripper has been removed in the view to permit the die to be shown more clearly. The concave shear

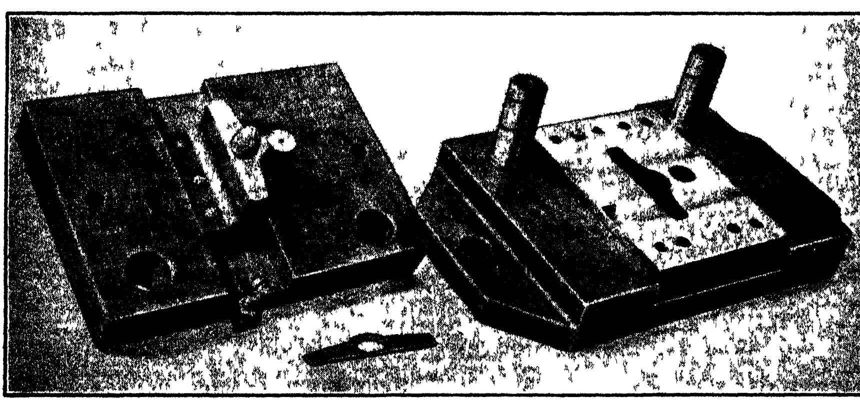


Fig 120 —Progressive tools with sheared die face.

is, of course, readily ground, and the die is therefore easily kept in good condition for operation.

Piercing a Slot

Piercing dies are often required for forming irregular openings, long slots, and the like as well as for making round and square holes in the work. An example of a particularly neat set of tools of this character is represented by the piercing and blanking progressive die in Fig. 121. The piece blanked and pierced is shown by the detail, Fig. 122. This is a sheet steel typewriter part $\frac{3}{64}$ in. thick and is later bent in forming dies

to finished shape. Only the blanking and piercing tools will be shown at this point, however.

The well-proportioned punch and die parts are all shown in the assembly drawing, Fig. 121. The interesting feature of the tools in the present connection is the provision for piercing the opening at A, Fig. 122, with the punch A^1 and die A^2, Fig. 121, so that when the work advances to the blanking position, the cutting out of the blank is accom-

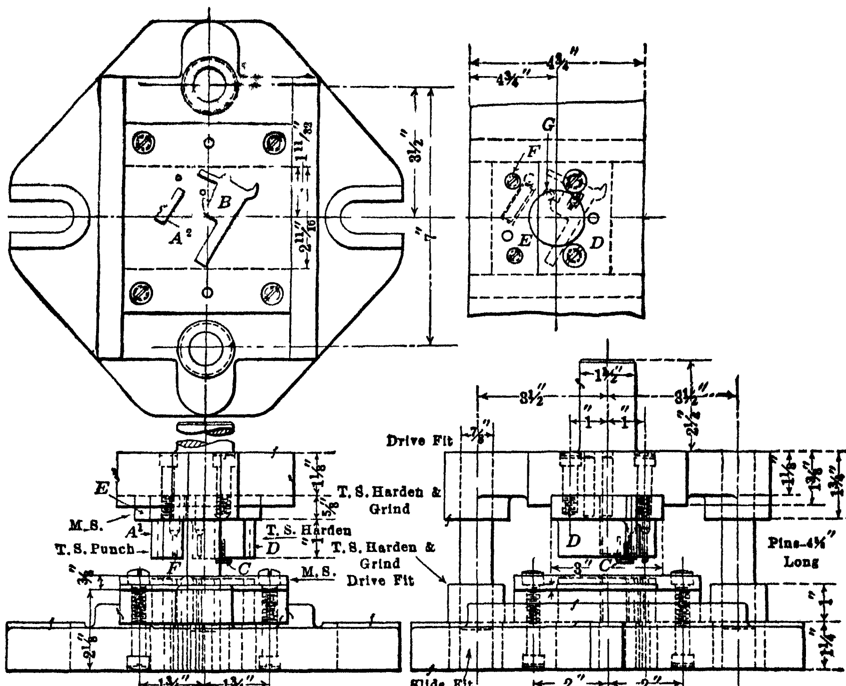


FIG. 121.—Piercing and blanking tools for a typewriter part.

plished in die opening B by the punch which shears across the lower end of the slot A, Fig. 122, and thus leaves that slot open at the end as required. This is a method frequently resorted to where one or more narrow slots are required with one end open as in the form of, say, a toothed comb; the oblong openings or slots can be pierced as completely enclosed holes, and at the next stage or blanking process the ends are opened by the blanking out of the piece.

There are also in the blank shown two small, round holes which are pierced by the two inserted punches 0.096 in. in diameter. The pilot for locating the work for the blanking is a rectangular piece shown at C which is fastened by a screw and two small dowels to the face of the blanking punch D.

The blanking punch is made in one piece of tool steel as indicated. The tool steel piercing punch A^1 for the slot is inserted in a separate steel plate E which is also bored to receive one of the small round punches F. The other small round punch G is inserted in a hole bored in the body of the blanking punch D. Each of the two punch bodies D and E is secured by two fillister head screws and two dowels fitted in from the top of the punch holder. Both punches fit snugly in the seat planed out 3 in. wide by ¼ in. deep in the face of the punch holder. With the divided construction shown it is possible if required to grind and lap the joining edges of the punch bodies to bring the spacing between centers to closest degree of accuracy.

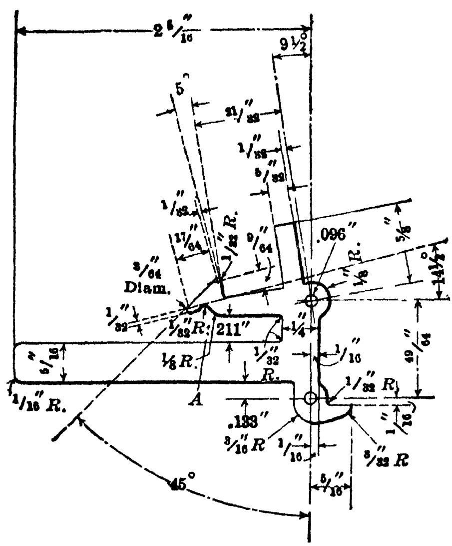


FIG. 122.—Detail of blank produced in the tools in Fig. 121.

It will be apparent from the plan view of the die that the position of the work as pierced and blanked is such as to take a minimum of stock, the angle to which the piece is set allowing the hooked projection to be blanked from the tongue left by the preceding blank.

A Three-stage Set of Dies

Piercing operations in progressive dies are oftentimes combined with other work than merely blanking, three or four distinct sets of tools being then carried in the one pair of holders so that the job advances from one die to the next until completed, just as with the piercing and blanking tools already illustrated.

An illustration of a piece of work requiring piercing, forming, and blanking as produced in a progressive die is shown by Fig. 123. This is a counter-sunk washer made from ⅛-in. rolled stock.

The dies are seen in Fig. 124, and the trigger gage or stop for automatically locating the stock is shown by the detail in Fig. 125. The counter-sinking to 60 degrees was originally performed in the drill press, but this was found a comparatively slow process, and so the press tools were designed as shown to take care of the counter-sinking also, this present arrangement producing 3,500 large counter-sunk washers and 7,000 ½-in. plain washers per hour. The latter are blanked out from the space left between the large washer blanks, as indicated in Fig. 126, which shows the scrap and gives an idea of the small amount of steel wasted in the work.

The large washer shown pierced and drawn down at *A*, Fig. 123, has been passed through the first operation in the die *N* and punch *L*, Fig. 124. The surplus stock is here drawn to the bottom by the punch *L* which, continuing downward, pierces a $\frac{7}{8}$-in. hole through the stock. Upon the up-stroke of the punch the strip of steel is advanced to allow the blanking punch *H* to remove the $\frac{1}{2}$-in. washer. At the same time the first operation is repeated.

As the stock again advances it comes to the punch *G* and die *P*. The dished stock shown at *A*, Fig. 123, is now flattened, forming the desired

FIG. 123.

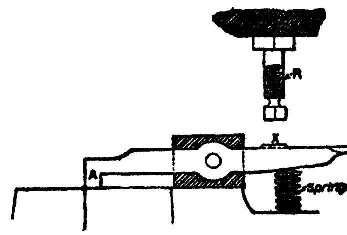


FIG. 125.

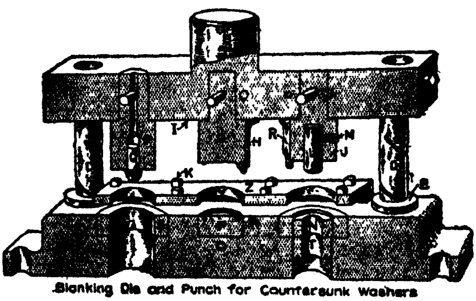


FIG. 124.

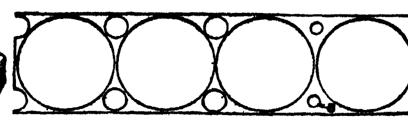


FIG. 126.

FIGS. 123–126.—Blanking die and punch for countersunk washers.

counter-sink, and at the same time it is embossed by the punch *G* and the die *P*. As the stock is advanced for the third operation the counter-sunk washer is blanked out by the die *S* and the punch *F* which is provided with a pilot *Q*, inserted in the manner shown.

The punch holder *B* is made of cast steel, and the die plate *C* of cast iron. They are properly alined by the guide pins *D* and the bushings *E* which are pressed into position and lapped to fit the guide pins. Under operating conditions the guide pins are well lubricated. The punches *F*, *G*, *H*, *R*, and *J* are held in position by taper pins. The dies are pressed into position in their seats in the die plate *C*.

The stripper *Z* is held in place by cap screws *K*. The perforating punch *L* is secured by the headless screw *M*. The die *N* is adjustable vertically in its seat by means of the threaded sleeve *T*. Small pinholes in the bottom and a pin spanner are provided for purposes of adjustment.

To refer again to the trigger stop or gage, Fig. 125, this works automatically under operating conditions by the proper adjustment of the set

screw and lock nut *R* which is here seen in the side elevation of the automatic spacing gage. As the punch descends, the screw strikes at *X* and causes the inner end of the gage *A* to be raised out of the hole *B*, Fig. 126, in the edge of the stock.

Dies with Spring Plate or Stripper for the Punches

The tools in Fig. 127 for piercing the six holes in the plate, Fig. 128, resemble somewhat in appearance a compound die in that they carry a

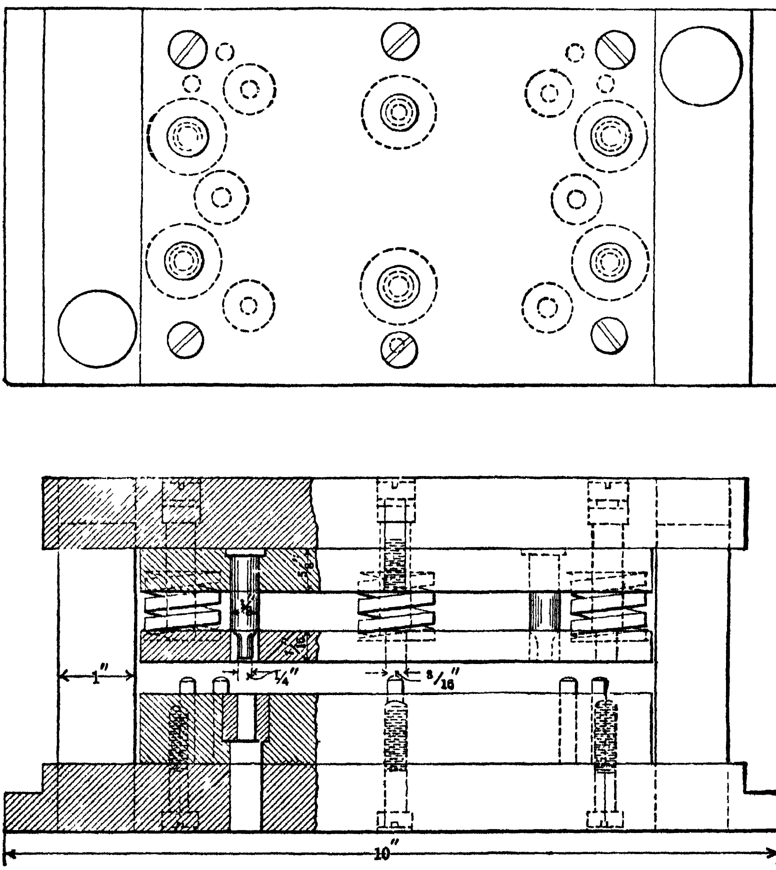


Fig. 127.—Multiple-piercing tools for a sheared plate.

spring-actuated pressure pad and stripper for the punches. The latter are $\frac{1}{4}$-in. diameter, and the plate operated upon is a steel member $\frac{5}{32}$ in. thick for a coin register. The dies are for piercing only as the piece is blanked in a previous operation.

The six dies are inserted in the steel plate as indicated, and the die holder fastened by screws and dowels to the base plate. The punches are made with $\frac{3}{8}$-in. bodies and with enlarged head so that they are seated in

the steel punch plate which is itself attached to the main head by fillister head screws and dowel pins. There are six heavy springs for controlling the stripper plate.

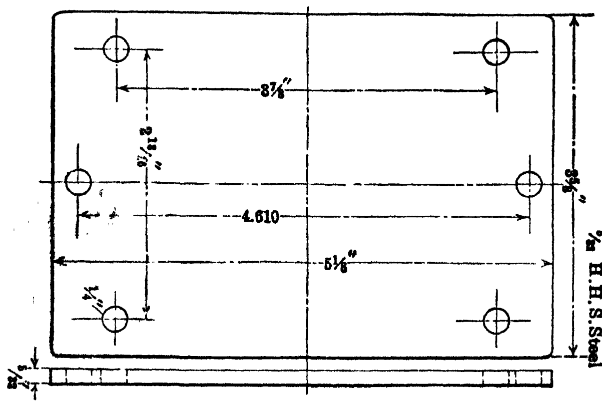


FIG. 128.—The plate as pierced with the tools in Fig. 127.

The locating stops for the work are a series of $\frac{3}{16}$-in. pins inserted in the die as shown.

This type of die is used extensively for various classes of work where holes are required to be pierced in parts already blanked. The general

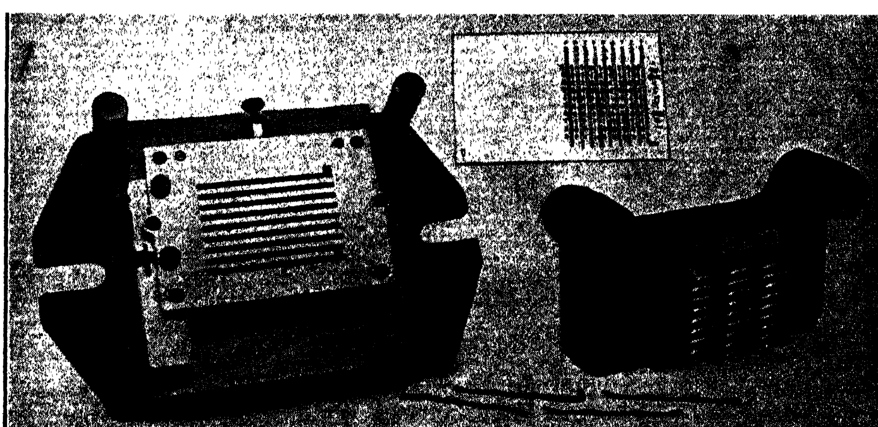


FIG. 129.—A sectional die for piercing a series of slots.

arrangement of the punches and stripper is quite similar to that found in the construction of the smaller set of tools in Figs. 100 and 101 for perforating the bottom of the article there shown. The dies in Fig. 127, however, are of the pillar type which insures alinement of the tools at all times. The arrangement of the springs for the stripper is along the lines followed

very often with compound dies where work is blanked and pierced at a single stroke in distinction from the follow dies shown in this chapter where the piercing is done first and the stock then advanced to a second position for the blanking out of the piece.

Details of construction of compound dies are taken up in the chapter that follows. There are a few more types of piercing dies to be shown in the present chapter, and one of these which embodies some very interesting features is represented by Fig. 129.

A Sectional Slot-piercing Die

The press tools in this view accomplish the piercing of the series of nine slots in the steel cover plate shown in the background of the photograph.

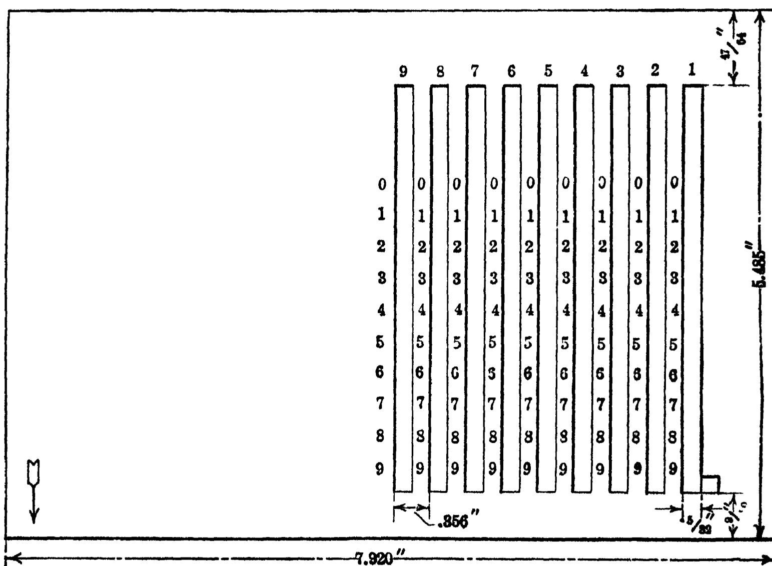


Fig. 130.—The work with slots pierced.

The piece is afterward formed up for a dial cover for a calculating machine. It is cut out first to a blank 7.920 by 5.485 in. as in Fig. 130 and is then stamped in dies which mark the numerals seen between the slots and at their ends. The slots are then formed with the piercing dies, Fig. 129, an operation that naturally follows the stamping in of the characters in the face of the blank in order to avoid the distortion that would be caused by the stamping of the numbers if done after the slots were made.

The slots are practically $\frac{5}{32}$ in. wide, and the width occupied by one slot and the adjoining stamped section is 0.356 in. The punch and die are shown with stripper removed in the view in Fig. 131, and a plan view of

the inserted sections for both members is given in Figs. 132 and 133. The view, Fig. 131, shows the stop gage and guide for the blank at rear and side. The drawings, Figs. 134 and 135, show respectively longitudinal and cross sections, and a detail of one of the punch and die sections is reproduced in Fig. 136. The different drawings referred to give a clear idea of all construction features.

The Die Parts

From Figs. 132, 134, and 135 it will be seen that the tool steel die sections are let into a steel plate or holder which, in turn, is secured in a seat in the base casting by means of fillister head screws. Here the die sections

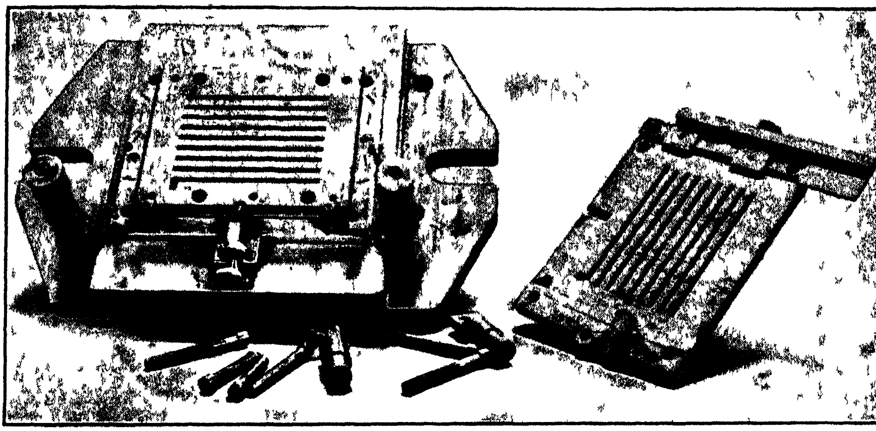
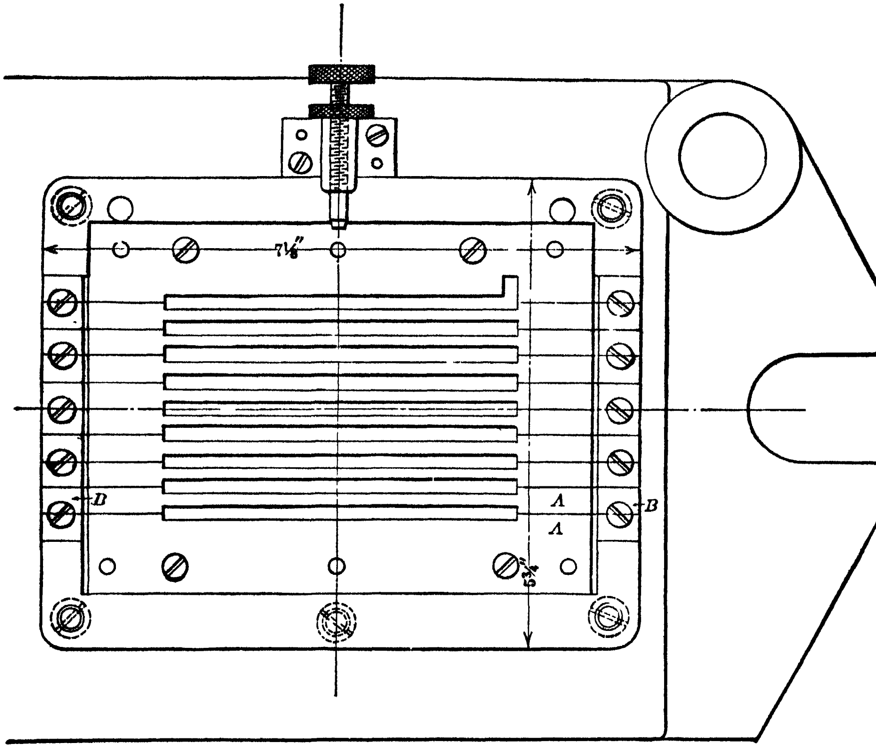


Fig 131 —Sectional-slot die details

or blades *A* are fitted snugly together and clamped at the ends by the steel strips shown at *B*. The die sections are made with their ends of the right width to give the exact spacing required between slots, and the narrow central portions are finished precisely central with the widened ends. They are finished ½ degree taper on the sides to give the clearance desired between them, or the same as if they were all worked out from a solid piece of tool steel.

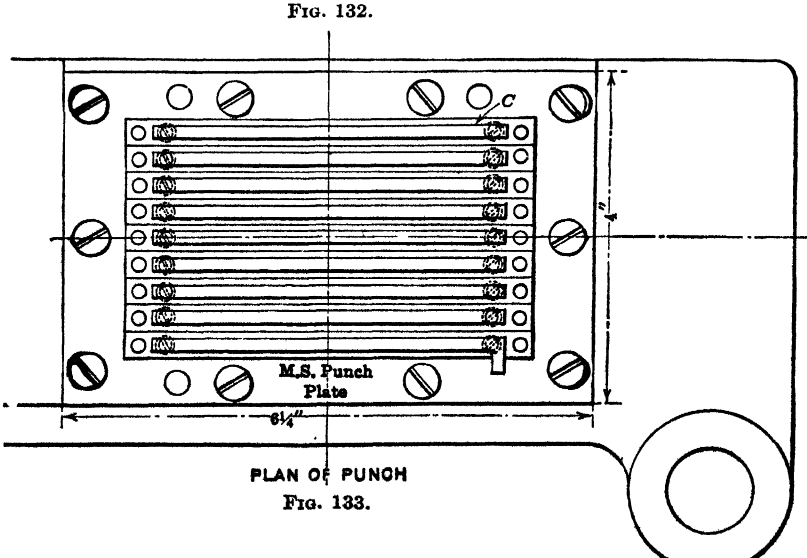
The sections were milled out from stock of suitable width, a few thousandths being left for grinding and lapping to exact dimensions; then they were hardened and drawn and then placed on the magnetic chuck for surface grinding. This was followed by lapping dead to size.

It may appear that the sections could have been made simpler for facilitating the finishing processes, but there are certain decided advantages with the form shown where the long body is central with the wide ends. For instance, the simplest method to occur to one might be the construction at *X*, Fig. 137, where the die blades *a* are straight from end to end and are spaced by blocks *b* equal to the width of slot required in the



PLAN OF DIE

FIG. 132.



PLAN OF PUNCH

FIG. 133.

FIGS. 132–133.—Plan of slot-piercing punch and die.

work. This arrangement, however, multiplies the number of parts and increases correspondingly the number of surfaces to be finished accurately; moreover, once completed, there is some question if there might not be a tendency for the long blades to spring away slightly from the bearing joint between the spacing sections, thus giving a less rigid construction than the one actually employed.

Another possible design is represented at *Y*, Fig. 138. Here the recess for the die opening is all at one side of the section, the ends being of the

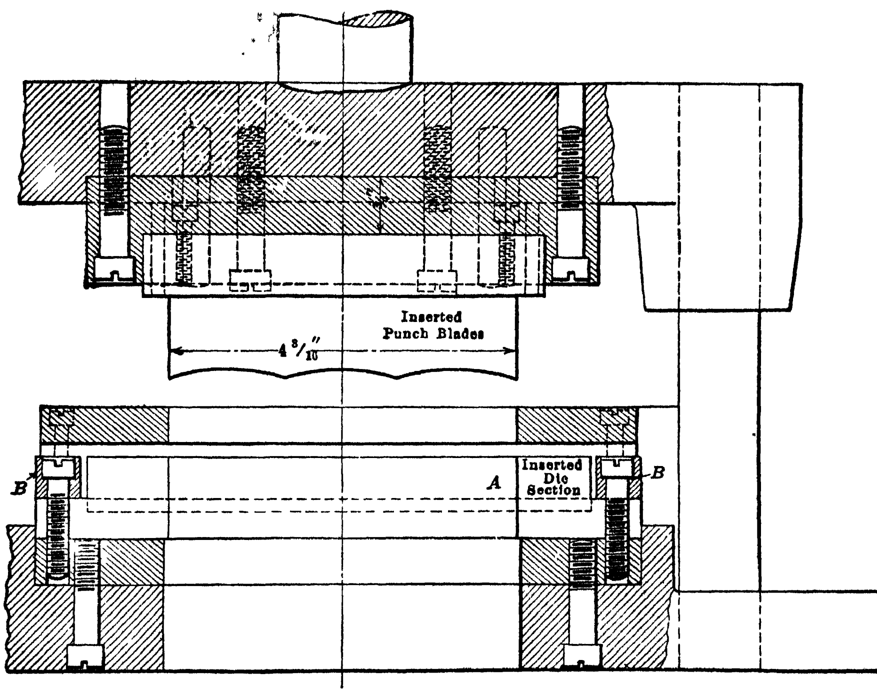


FIG. 134.—Longitudinal section through punch and die.

same width as when the symmetrical form of Fig. 132 is used. While there is some advantage here in doing all the cutting in of the metal from one side with a plain flat surface opposite, there is still a difficulty in connection with the hardening that is likely to offset this in a measure. As with any member that is offset, eccentric, or so shaped that the cross-sectional area is unevenly distributed in relation to the axis of the piece as a whole, there is likely to be distortion when the work is hardened, and this necessitates provision for the removing of more material by grinding after the work has been through the fire. Experience on other work with the two forms of die sections at *X* and *Y* led the designers of the sectional die described to use the form of inserted member illustrated in Fig. 132.

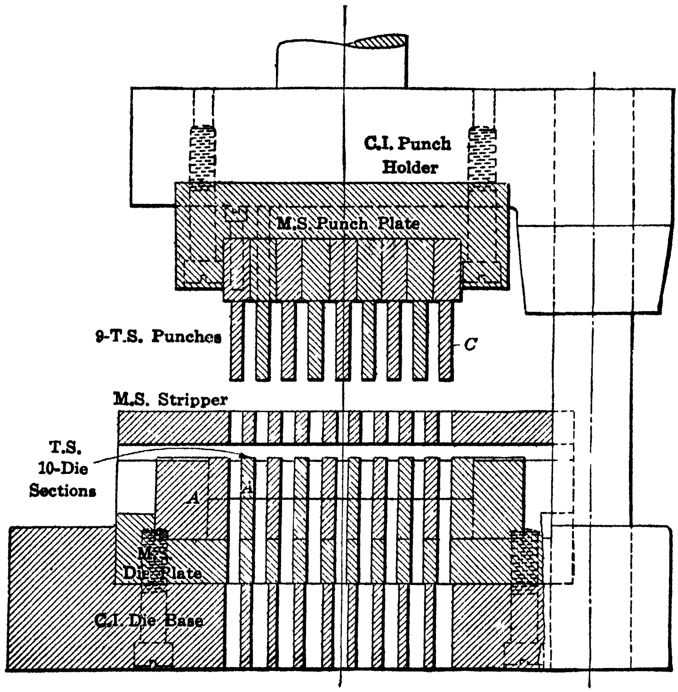


FIG. 135.—Cross section through punch and die.

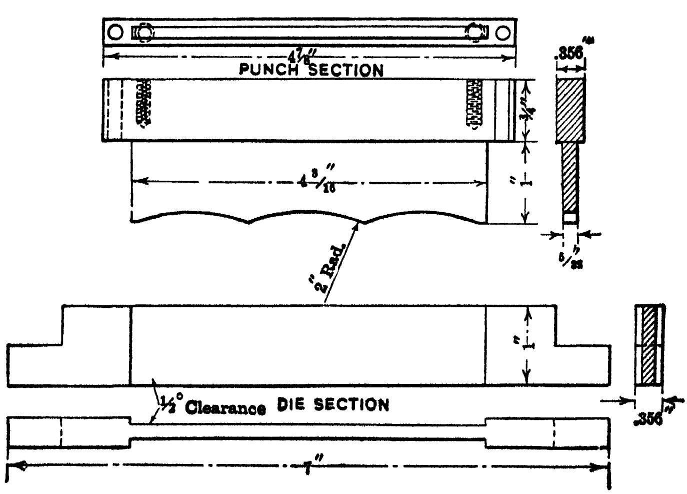


FIG. 136.—Detail of punch and die parts.

The Punches

The form of the punch sections is shown by the drawings to be symmetrical also, the blades being placed centrally with their backs and permitting of ready machining and of accurate finishing by grinding and lapping.

These punch sections are secured as at *C*, Figs. 132 and 135, in a steel holder or plate which is machined out to let the sections enter as a snug fit when finished to correct length and thickness. The punch sections are also secured by small fillister head screws and dowels as represented in the plan view.

The flat steel holder or punch plate is $\frac{3}{4}$ in. thick through the bottom and is itself fastened to and located on the cast head by screws and dowel

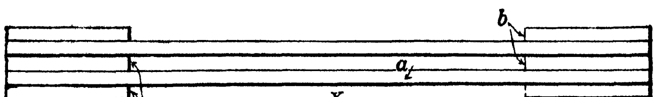


Fig. 137.

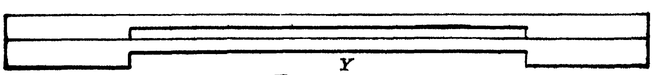


Fig. 138.

Figs. 137–138.—Other possible forms of die sections.

pins. The two members, base and head, of this set of tools are alined and kept in condition by the large guide posts or pillars at the back.

The punches, it will be noticed, are adapted for a shearing cut on the metal, by having three concave portions along their cutting edges which are ground in with the circumference of the wheel so that they are kept sharpened as readily as if they were of the conventional flat form. This method of shearing allows the work to be slotted with the narrow, closely spaced punches without danger of "dragging" the metal and producing rough, irregular edges along the slots.

Side-piercing Tools

There are instances where work, cylindrical or other, requires piercing from the side, and the punches in such cases are operated radially or toward the center of the piece by tapered or bevel-faced plungers carried by the upper member of the die set and acting against pressure springs which return the punch slide to normal position upon the up-stroke of the press. A typical case is illustrated by Fig. 139.

In some cases a large number of holes are pierced simultaneously through the work by the necessary number of punches all carried by sliding members operated in similar fashion to the ones described. And these side piercing punches may be designed to be operated either toward

the center by some form of closing-in device or, on the other hand, expanded and forced outwardly by a tapered plunger or its equivalent at the center. The direction of the working stroke of the punch depends upon the size and character of the piece to be pierced.

With reference now to Fig. 139, this shows a set of piercing tools for punching two holes in opposite sides of the square tube seen at the right in the drawing, Fig. 140. The tube is of steel, $\frac{15}{16}$ in. square inside, and the method of supporting in the dies is to slip the piece of work over the member *A* which may be called a horn die in this instance, as it projects

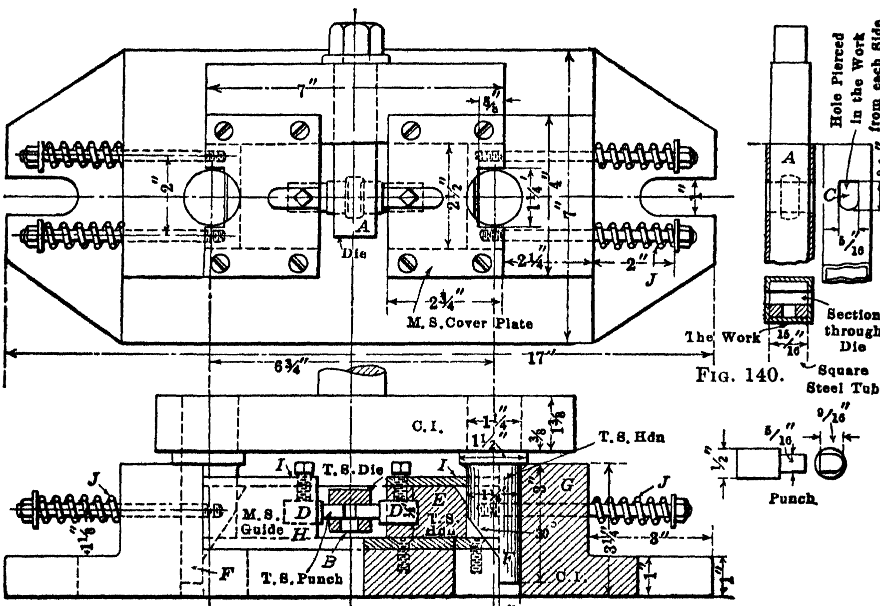


FIG. 140.

FIG. 139.

FIGS. 139–140.—Side-piercing tools.

in the form of a bar from the shank which is fitted in the wall at the back of the die base. The support *A* is finished out through the sides to form the die openings, and a slot is cut in the bottom at *B* to allow the slugs to drop through. The shape of the die is seen at *C* where the hole is shown $\frac{5}{16}$ in. wide by $\frac{9}{16}$ in. long with the front end formed to a half circle.

THE PUNCHES AND HOLDERS

The two side-piercing punches are set into holders as at *D*, the blocks *E* being adapted to travel longitudinally to force the punches through the work when the plungers *F* descend with the down-stroke of the press slide. These plungers are secured in a regular punch holder or head and are of tool steel, hardened. They are machined to an angle of 30 degrees for a

portion of their length, and a corresponding slope is formed upon the rear ends of the punch slides *E, E*. The plungers *F* are cylindrical except for the sloping portion referred to, and they fit so as to slide closely in holes bored in the die shoe which at the ends is cast with a rectangular boss or projection *G* to provide sufficient height for a satisfactory guide for the plungers or pins *F*.

The casting is originally made with portion *G* wide enough to allow the full diameter of the hole to be bored down through and is afterward planed away at the front, as indicated, to form clearance and allow the plunger to act against the beveled end of the punch slide *E*.

The two punch slides *E, E* are of tool steel, hardened, and they slide in machine steel guides *H* which are secured by counter-sunk head screws and dowel pins to the die shoe. The slides are $2\frac{1}{2}$ in. wide, and when fitted to their horizontal guides they are prevented from lifting by cover plates 1 which are held by fillister head screws to the guide block. The cover plates are slotted at their inner ends to clear the tops of the set screws for holding the piercing punches.

The slides with their punches are withdrawn upon the up-stroke of the press by means of the compression springs *JJ* which are located upon studs tapped into the rear of the slides and fitted freely in holes drilled horizontally through the casting at *G*. The springs act against the washer and nut at the outer end of the studs and thus force the studs and punch slides outward when the bevel plungers are returned to their upper position.

Tools for Piercing Oblique Holes

Following along to other special forms of piercing tools, we come naturally to the problem of piercing holes at an angle, and one set of tools for this purpose which should be helpful in the way of a suggestion for handling various jobs of similar character will be seen in Fig. 141.

This die was designed to pierce two $\frac{1}{8}$-in. holes at an angle of 40 degrees through the arc-shaped piece in the upper corner of the engraving. The cast steel blank holder *A* in these tools is suspended from the cast iron secondary ram *B*, or upper member of the dies, by the guide pins *C* which are pressed into *A* and made a sliding fit in *B*. The springs *D* transmit power for the blank holder *A*. The links *E* are hinged on the member *B* and on the punch operating members *F*, which in turn are pivoted in the lugs cast integrally with the blank holder.

The punch holders *G* which are a sliding fit in *A* carry the two piercing punches *H*. The hardened steel pin *I* is pressed into the punch holder *G* and serves as a rest for the forcing device *F* which is cut out square to allow for the angular movement of the punch holders. The button dies *J* are pressed into the cast iron base *K*.

The drawing shows the die at the bottom of the stroke. The die operates as follows: The blank holder *A* and the secondary ram *B* descend as a unit until the blank holder strikes the piece to be pierced, holding it securely on the die. The secondary ram *B* continues its downward course, setting the toggle arrangement in motion, thus piercing the holes. On the return stroke the ram *B* ascends, withdrawing the piercing punches and stripping the work. The blank holder remains stationary until the

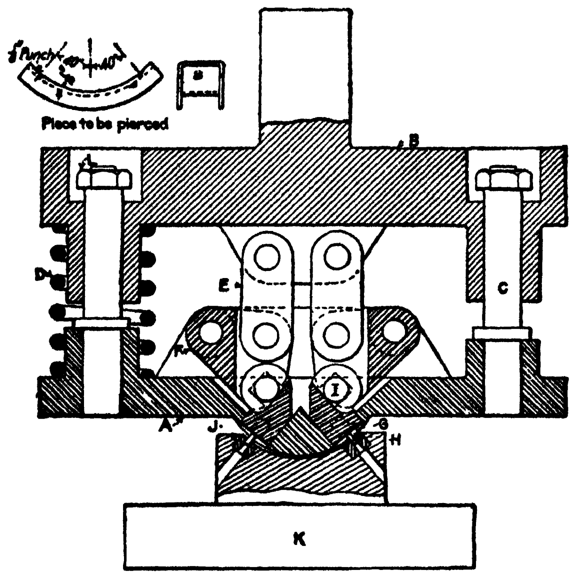


FIG. 141.—Dies for piercing oblique holes.

nuts *L* bottom in the counter-bored holes. The ram and holder then ascend together.

BLANKING AND PUNCHING STAINLESS STEEL

Table 5 presented on an earlier page in this chapter gives the approximate pressure for punching mild and high-carbon steels. A corresponding table reproduced here (see Table 12) covers the punching pressure for 18-8 stainless steel and shows that this particular type of stainless steel requires about 40 per cent more power than the ordinary grades of steel of similar gage. Then too, speeds of press operation should be lowered to about two-thirds of that used for mild grades of steel. Harold J. Flynn,[1] writing on this subject, states that in punching and blanking, the clearances for chromium-nickel steels should be set closer than for mild steels; for light gage stainless steel they should be between 0.0015 and 0.0025 in. maximum, and for heavier gages clearances of 0.0025 to

[1] In *American Machinist.*

0.0040 in. are considered good practice. These clearances compare favorably with the figures given in Table 2 for 5 and 6 per cent allowances based on stock thicknesses for mild steel up to about 0.100 in. thick. As with the latter type of steel the exact clearance for stainless steel is a matter for experienced judgment to determine. The text preceding Table 2 explains that 5 or 6 per cent of the gage thickness is commonly employed for fixing clearances for tools for soft and medium rolled steel where small, accurate work is under consideration.

The shear of the punch should not be excessive, but it should put the metal under slight tension just before cutting action starts. Present shop practice indicates that this shear is no greater than the thickness of the metal. Because of the higher ductility and elongation of chromium-nickel grades, the shear may be slightly increased over standard practice with mild steels in order to provide a slight breaking through and to speed the cut. Both punch and die may be made of the same type of steel, either an air- or oil-hardening tool steel being preferred.

In one-level punching of holes, suggested pressures in the table may be multiplied by the number of holes to be punched. The resultant tonnage should not exceed about two-thirds of the rated press capacity. If the punches are offset or stepped about one-half the thickness of the material, the total pressures can be divided by the number of steps in the arrangement. Figure 142 shows different punch levels.

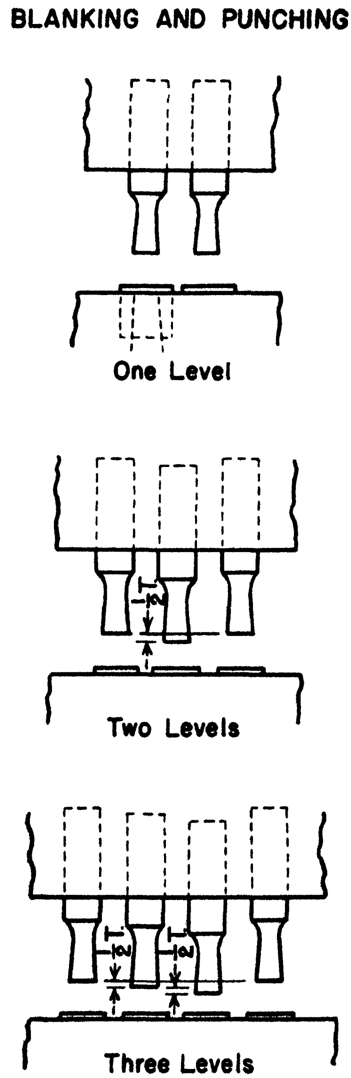


FIG. 142.—Punches stepped one-half the metal thickness reduce punching pressure.

The above authority states that press speeds should be reduced to one-half or one-third of the speeds of mild steel practice and the power should be increased about 75 per cent to perforate stainless steel satisfactorily. It is advisable to attempt to perforate straight chromium steels where the holes are smaller in diameter than

stock thickness and chromium-nickel steels where the diameter of the holes is less than 1½ or 2 times the metal thickness. After perforating it may be necessary to flatten or anneal the work for certain applications.

Handling Other Materials

Following the data presented on blanking and punching stainless steel it will be well to devote some space to similar operations on other materials, for example, aluminum and such nickel-base alloys as Monel and Inconel; details of handling laminated plastics are included also at this point.

According to accepted authorities, power to shear Monel, nickel, and Inconel has been found to run from 113 to 119 per cent in the soft tempers and to about 130 per cent in the full hard tempers of that needed to shear mild steel of equal gage. Shear blades must be set up tight and kept sharp.

For perforating, soft to skin hard temper is the preferable material to employ, and punch clearance should be the same as for neat steel punching. For ¼ in. and heavier material it is desirable to use slightly less clearance than for steel in order to produce a clean hole free from burrs. A close clearance should be maintained between the punch and the stripper plate.

The minimum size hole that it is practicable to pierce in given thickness of soft to quarter-hard temper sheet is as follows:

Thickness of Sheet	Approximate Minimum Diam. of Hole
0.018 in. to 0.034 in.	Thickness × 1.5
0.037 in. to 0.070 in.	Thickness × 1.3
0.078 in. to 0.140 in.	Thickness × 1.2
$\frac{5}{32}$ in. and heavier	Thickness × 1.0

Punches and dies should be made of alloy steel, heat-treated to a tough temper of about 58 to 61 Rockwell C. A heavy sulphur-base oil should be used in punching. It must be thoroughly removed before the perforated sheet is heated for annealing or any other purpose. From 15 to 20 per cent more shear loss is required to perforate these high-nickel alloys than is needed for mild steel of equal gage.

Some Aluminum Data

In discussing the subject of blanking and punching sheet aluminum, J. T. Weinzierl and A. C. Heintz of the Aluminum Company of America give some interesting facts regarding the handling of this material in the press, particularly in reference to lubrication of both sheet stock and punches and dies and its importance in keeping down the costs of tool maintenance.

They recommend, in an article in *American Machinist*,[1] a medium grade of engine oil plus a small percentage of fatty oil diluted with kerosene, and state that this has been found to give best results when hard aluminum sheet is being blanked. With blanking of a softer alloy or temper the engine oil and fatty oil mixture is used without dilution.

It is stated that by pulling the sheet metal between saturated felt pads a thin film of oil is spread over the work; the pads are usually attached directly to the die or to the press bed so that lubricating will be done just before the metal passes under the dies; also a felt ring may be placed around the punch just above the spring-actuated stripper which clears the metal from the punch—where this form of stripper is used, instead of a stripper attached directly to the die—and thus the punch is lubricated directly by the oil trickling down to its cutting edge.

In regard to clearance between punch and die for piercing operations, the table and explanatory matter on pages 55 and 56 Chapter II, show that for usual brass and soft steel punching, for close work, an allowance or clearance between punch and die of 5 to 7 per cent of stock thickness is fairly customary. The above authors point out that for small aluminum piercing where slugs are inclined to stick to the punch and lift with it on its upstroke the difficulty is overcome by holding clearance to 5 per cent.

The stripper for blanking punches is often spring mounted on the punch as indicated above. It tends to hold the stock like a pressure pad, and as it is flush with the end of the punch it strips it neatly without danger of warping the strip of sheet stock.

PRESS WORK ON PLASTICS

Punching, blanking, shearing, and shaving are done extensively on laminated plastics and, to some extent, on other plastic sheets and tubes. The following applies to *laminated* materials: Punching and some other operations vary to some extent with thickness of sheet, character of filler used, and temperature of the sheet. Some sheets can be punched cold, up to a certain thickness. Others require heating; usually the thickness which can be punched is greater when the sheet is hot. Heating can be done on hot plates or in ovens, but should follow the recommendations of the particular maker, both as to temperature and length of heating. Some makes can be heated to as much as 280°F. without injury and others only to 250°F. Too high a temperature may affect the finish of the sheet and too long a heating may make it brittle. Punching should be done within 2 min. or less after heating.

Laminated materials yield somewhat when punched, the hole produced being slightly smaller than the punch. Allowance of about 3 per

[1] J. T. Weinzierl and H. C. Heintz in *American Machinist*.

cent of thickness punched (others say 0.002–0.003 in. for each $\frac{1}{32}$ in. in thickness) must be made for this in punching as well as in blanking. A very close fit between punch and die (approaching a sliding fit for cold work) is required. Stripper plates also should fit the punch closely to prevent lifting at the edge of the hole as the punch is withdrawn. Some recommend that dies be tapered $\frac{1}{4}$ degree to a point $\frac{1}{8}$ in. below the surface to minimize splitting around the edge of the hole. Progressive dies often are satisfactory, but best results are secured with compound dies which place a spring load on the stripper. Blanking punches should be from 0.001–0.008 in. smaller than the size of blank required. Press speeds of about 150 strokes a minute usually are advocated.

Punched blanks often have rough edges. This can be remedied by *shaving* in a hollow die with a 45-degree cutting edge, which must be sharp, using a brass or soft steel plunger. Shaving is done hot as a rule, but can be done cold on some materials up to about $\frac{1}{8}$-in. thickness; although heating in oil or water is advocated.

Shearing of sheets up to $\frac{1}{8}$ in. thick can be done hot; some grades up to $\frac{1}{16}$ in. can be sheared cold. Thin sheets can be sheared on hand presses designed for cardboard, but thicker sheets are sheared on power presses. They should be clamped securely close to the knife. Shear blades must be sharp and without clearance; otherwise thin stock tends to creep as the blade progresses across the sheet. Rotary shears can be used for cutting thin strips, but the latter also are cut quickly and accurately on slitting machines. Thick sheets usually are cut by sawing.

Punching, blanking, and shearing of *thermoplastics* is feasible in some cases, but such cutting commonly is done with a knife having a sharp beveled edge. *Hard rubber* of some compositions can be punched in thin sheets, using a female die; some work is done hot and some cold. Allowance for shrinkage is required for hot work. Punches having a cutting edge also are used. These have about $\frac{1}{64}$ in. clearance inside to allow the punching to come up through the punch. The latter sometimes having a spring or soft rubber ejector. The outside edge of such punches is tapered about 10 degrees from vertical. Sheets must be heated and cooled uniformly to avoid warpage, cooling under weight often being necessary.

Cellulose acetate sheets also can be punched and blanked with sharp edge tools. To obtain smooth edges the sheet is warmed to about 125°F., not enough to affect its polish. As the material is compressed by the cutting action, one edge is concave and the other convex, but this is hardly noticeable on thin sheets. Considerable blanking is done on *pyroxylin* plastics, which work much like cellulose nitrate, the material being warmed and sharp edge punches employed. *Lucite* is blanked similarly, but heating to 180°F. is recommended for this type of material.

TABLE 12.—PUNCHING PRESSURE FOR 18-8 STAINLESS STEEL

Thickness, gage	Hole diameter, in.														
	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
20	0.43	0.80	1.07	1.32	1.60	1.80	2.10	2.40	2.70	2.90	3.15	3.45	3.75	4.05	4.20
18	0.71	1.06	1.41	1.80	2.10	2.55	2.75	3.15	3.60	3.90	4.20	4.65	4.95	5.25	5.70
16	0.89	1.34	1.80	2.25	2.70	3.65	3.60	4.05	4.35	4.80	5.25	5.70	6.15	6.60	7.05
14	1.11	1.65	2.25	2.75	3.30	3.90	4.35	4.95	5.55	6.10	6.60	7.20	7.80	8.25	8.85
12	1.50	2.40	3.15	3.90	4.65	5.40	6.15	7.05	7.80	8.55	9.30	10.05	10.80	11.55	12.45
11	1.80	2.70	3.60	[illegible]	5.25	6.15	7.05	7.95	8.85	9.75	10.65	11.55	12.45	13.20	14.10
10	....	3.00	4.05	[illegible]	6.00	6.90	7.95	9.00	9.90	10.95	12.00	12.90	13.95	15.00	15.90
3/16	....	4.20	5.55	6.90	8.25	9.75	11.10	12.45	13.80	15.30	16.65	18.00	19.35	20.70	22.20
1/4	....	....	7.35	9.30	11.10	14.30	14.70	16.50	18.45	20.25	22.20	24.00	25.80	27.75	29.55
5/16	....	....	....	....	16.65	19.50	22.20	24.90	27.75	30.45	33.15	36.00	38.70	41.55	44.25
3/8	....	....	....	....	....	25.80	29.55	33.15	36.90	40.65	44.25	48.00	51.60	55.35	59.10
7/16	....	....		....	....	....	....	....	46.20	51.70	55.35	60.00	64.50	69.15	73.80
1/2	....	....	....	....	....	....	....	....	....	....	66.45	72.00	77.55	83.10	88.50

CHART FOR DETERMINING BLANKING PRESSURE*

There are two practical methods of determining blanking or shearing pressure: by the use of Fig. 143 or by use of a simple formula. When the blanking pressure is found for any job, it is then possible to select a press with sufficient tonnage rating. Moreover, the pressure required to form a part is never greater than the pressure required for blanking. And the pressure required to draw a part cannot exceed the tensile strength of the material, so that only the blanking pressure need be considered in selecting a press for the operation.

Use is as follows:

Given: Material—24ST aluminum, 0.051 in. thick. Part to be blanked, 3 in. in diameter.

1. Length of sheared edge $= \pi D = 9.42$ in.
2. Find 0.051 on Scale 1 (at point 1) and 9.42 in. on Scale 4 (at point 2).
3. Connect points 1 and 2.
4. The line connecting points 1 and 2 intersects Scale 2 at 0.480, or point 3.
5. From the table of shear strengths for various materials, it will be seen that the shear strength for 24ST is 40,000 lb. per sq. in.
6. From point 4 on Scale 5 (representing 40,000 lb. per sq. in.) draw a line to point 3 on Scale 2.
7. The line connecting points 3 and 4 intersects Scale 3 at point 5, giving a reading of 9.8 tons.

The formula for blanking pressure is

$$P = \frac{SLT}{2,000}$$

where P = pressure in tons
S = shear strength of material
L = sheared length in inches
T = material thickness in inches

When the above problem is calculated with the formula, the result is 9.6 tons. The error in reading is not important, because an error of 500 lb. would not impose

* Courtesy, University of California.

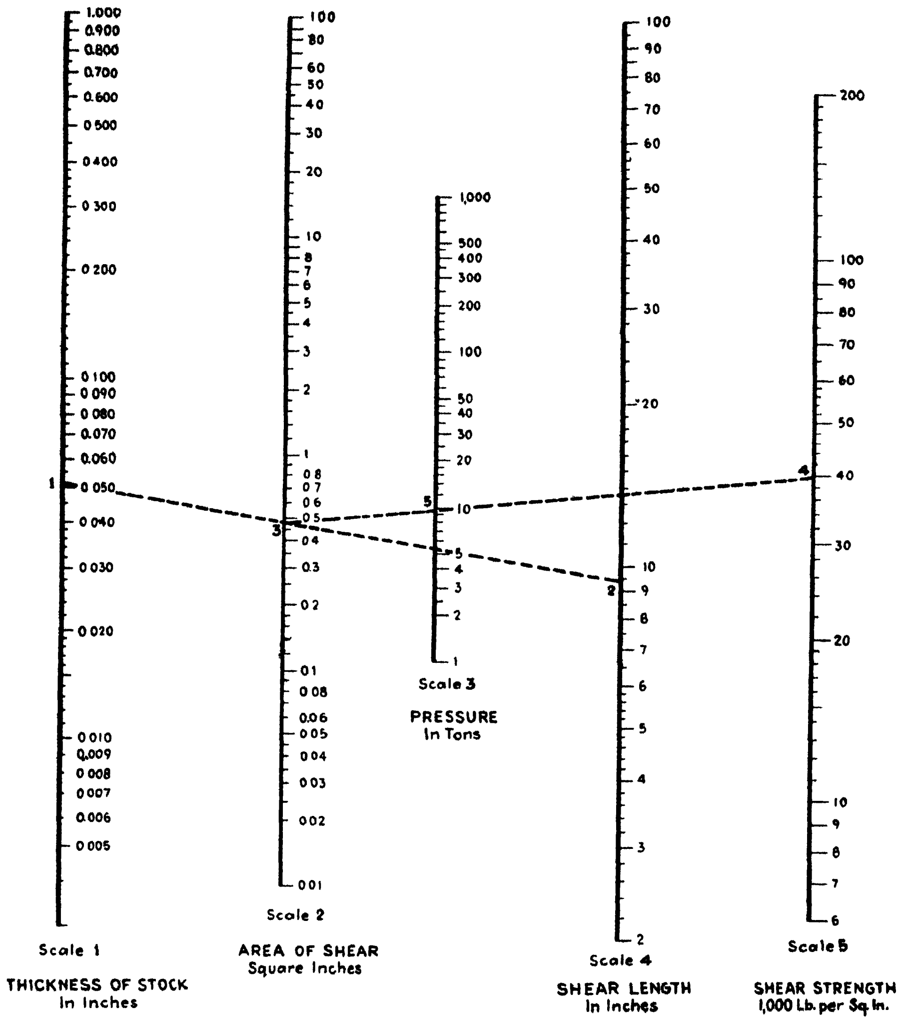


FIG. 143.—Chart for determining blanking pressure.

an excessive load on the press, considering the factor of safety used in the design of such equipment.

TABLE 13.—SHEAR STRENGTH OF VARIOUS MATERIALS, LB. PER SQ. IN.

Ferrous Materials

Carbon steel:	
Soft open-hearth annealed	42,000
Casehardened, SAE 1020 water-quenched and drawn to 400°F	60,000
SAE 1045 hardened in water, and drawn to 800°F	90,000
Chromium-molybdenum steel:	
SAE 4130 tensile strength, 90,000	55,000

TABLE 13.—SHEAR STRENGTH OF VARIOUS MATERIALS, LB. PER SQ. IN.—(*Continued*)

Ferrous Materials

Carbon steel:	
SAE 4130 tensile strength, 100,000	65,000
SAE 4130 tensile strength, 125,000	75,000
SAE 4130 tensile strength, 150,000	90,000
SAE 4130 tensile strength, 180,000	105,000
Nickel steel:	
SAE 2320 drawn to 800°F. and oil quenched	98,000
SAE 2330 drawn to 800°F. and oil quenched	110,000
SAE 2340 drawn to 800°F. and oil quenched	125,000
Nickel-chromium steel:	
SAE 3120 drawn to 800°F	95,000
SAE 3130 drawn to 800°F	110,000
SAE 3140 drawn to 800°F	130,000
SAE 3230 drawn to 800°F	135,000
SAE 3240 drawn to 800°F	150,000
SAE 3250 drawn to 800°F	165,000
Rivet steel	44,000
Structural steel	45,000
Wrought iron	40,000

Non-ferrous Materials

Aluminum alloys:	
2S-O	9,500
2S-¼H	10,000
2S-½H	11,000
2S-¾H	12,000
2S-H	13,000
3S-O	11,000
3S-¼H	12,000
3S-½H	14,000
3S-¾H	15,000
3S-H	16,000
4S-O	16,000
4S-¼H	16,000
4S-½H	18,000
4S-¾H	20,000
4S-H	21,000
11S-T3	30,000
17S-O	18,000
17S-T	35,000
17S-RT	36,000
Alclad 17S-T	32,000
Alclad 17S-RT	32,000
A17S-O	15,000
A17S-T	25,000
24S-O	18,000
24S-T	40,000
24S-RT	41,000
Alclad 24S-T	39,000
Alclad 24S-RT	39,000

TABLE 13.—SHEAR STRENGTH OF VARIOUS MATERIALS, LB. PER SQ. IN.—(*Continued*)

Non-ferrous Materials

Aluminum alloys:	
51S-O	11,000
51S-W	24,000
51S-T	30,000
52S-O	18,000
52S-¼H	20,000
52S-½H	21,000
52S-¾H	23,000
52S-H	24,000
53S-O	11,000
53S-W	22,000
53S-T	26,000
Brass, red:	
Tensile strength 85,000	43,000
Tensile strength 43,000	27,000
Brass, drawing:	
Tensile strength 46,000	30,000
Bronze:	
Tensile strength 37,000	25,000
Phosphor bronze:	
Tensile strength 45,000	33,000
Copper:	
Tensile strength 32,500	21,000

CHAPTER IV

TOOLS FOR CUTTING-OFF OPERATIONS

The different methods of producing blanks described in other sections of this book include certain details of cutting-off or parting operations, with the shearing tools either combined with others in progressive dies or acting alone for merely severing the strip of material or at the same time producing the desired shape for the ends of the blank.

The cutting-off die is adaptable to many classes of blank production where the width of the stock is suitable, that is, where it is of the width required for the blank and only the ends have to be sheared or cut to either a straight edge or some curved or angular form.

A number of examples of operations are included in the present chapter where the cutting-off tool completes the final stage in a progressive set of dies for piercing, slotting, or otherwise operating on the work which is completed without blanking in the usual manner.

Occasionally the piece is cut off before a final bending or forming operation is performed. In such cases the blank may be rested as cut off, upon a spring pad which descends under the action of the bending or forming punch.

Piercing and Cutting-off Arrangement

A set of tools for piercing several holes in the material and cutting to length are shown by Fig. 144. The blank made is in this instance 4 in. long by 2½ in. wide with five ¼-in. holes spaced as represented and a 1¼-in. hole punched near the center. The material is $\frac{1}{16}$-in. cold rolled steel.

The drawing shows most of the tool details clearly, and a brief explanation will answer all purposes. The stock is the width required for the work, and the strip of metal is held true against the guide at the back of the die by the projecting handle of the bent member *A* which forces the work squarely against the guide *B*. The method of locating the different punches for piercing and the cutting-off punch *C* will be seen from the drawing.

The cutting-off punch is, in this case, shown with a relieved or backed-off edge of about 8 degrees to give freedom of cut, and it might with equal ease be made with a sheared edge from front to back if the metal operated upon were sufficiently heavy to necessitate it.

The end of the stock, as it is passed through the stripper, is first trimmed off by the cut-off punch, and the strip of metal is then advanced against the stop D for cutting off to length. The first down-stroke of the punch has already pierced the work, and the first cut-off or trimming of

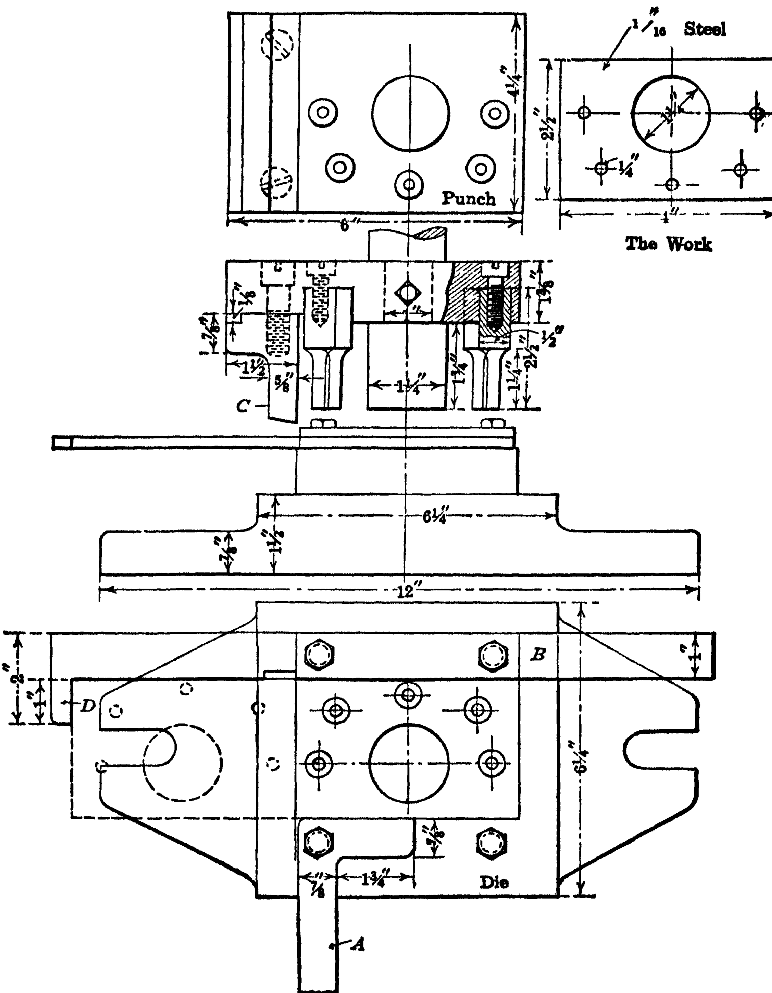


FIG. 144.—Piercing and cutting-off dies.

the end prepares the leading end so that each following down-stroke pierces the holes through the material while the preceding blank is severed by cut-off punch C.

There are numerous combinations of piercing punches and parting tools on work of this general character and various methods of securing

the punches to the holder. The method illustrated is only one of several satisfactory ways in which they may be inserted and fastened in place.

END-FORMING PARTING TOOLS

The dies in Fig. 145 represent an example of a set of cutting-off dies which at one stroke pierce holes in the ends for adjoining blanks and cut

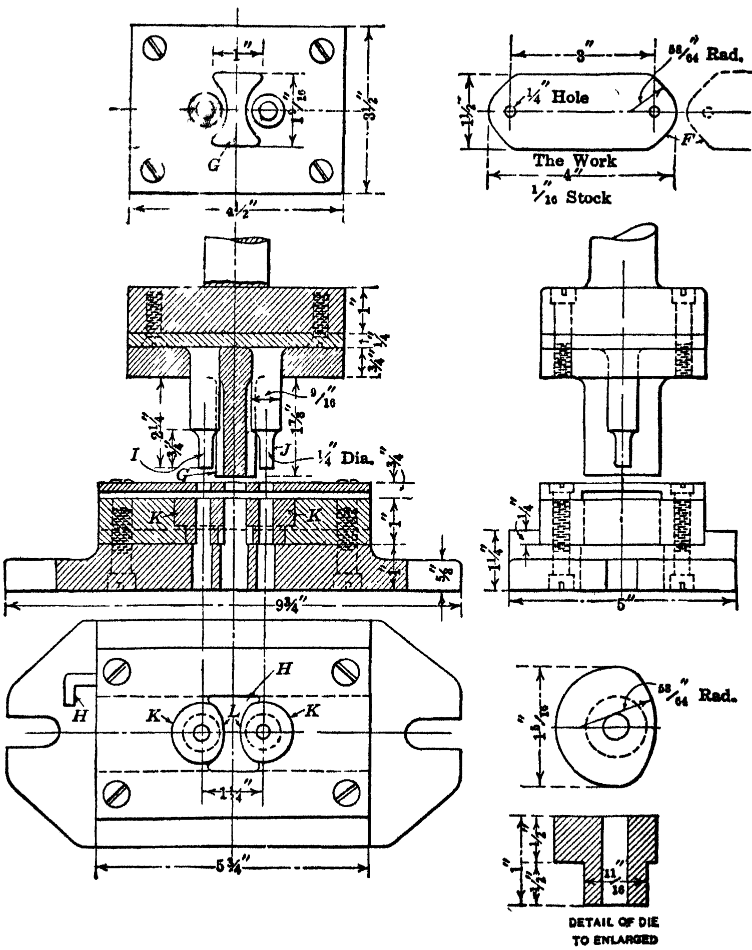


FIG. 145.—Cut-off dies for round ends.

the two pieces apart, at the same time shaping the ends to the round form *F*, shown at the upper corner of the drawing. The tools are arranged with a centrally located cutting-off punch and a piercing punch at either side.

As indicated at *G*, the central punch is in the form of a concave sided tool with section suited to the curves required on the ends of the pieces to

be cut off from the strip of stock. The material worked is $1\frac{1}{2}$ in. wide, and the punch is $\frac{1}{16}$ more or $1\frac{9}{16}$ in. from front to back. The piercing punches are located to pierce a $\frac{1}{4}$-in. hole at each side of the parting punch.

The strip of material to be used for the work is fed past the edge of the cut-off punch *G*, and the first stroke shapes the leading end of the work and pierces the hole in that end. Then the work is advanced to the gage *H*, and the next stroke of the slide causes the punch *I* to pierce the second end of the first piece, while the punch *G* cuts it off and shapes the end of the next piece, and the punch *J* pierces the $\frac{1}{4}$-in. hole for that piece. So for each succeeding operation of the punch a piece is completed and cut off.

The dies *KK* are inserted, as they are of the button type, and each is finished to a diameter of $1\frac{5}{16}$ in., with the front edge at *L* ground to the longer radius required or $\frac{55}{64}$ in. This facing of the die to the radius, given at the point of cutting only, makes it possible to use a smaller diameter of body for the die, and when the cutting portion becomes worn the die may be pressed out of its seat, a new portion of the edge ground to the radius of $\frac{55}{64}$ inch, and the die pressed back into new position for continued service.

A Slotting and Cutting-off Job

The tools in Figs. 146 and 147 are for a piece of work somewhat similar to that just shown except that the work in Fig. 147 has a slot pierced in

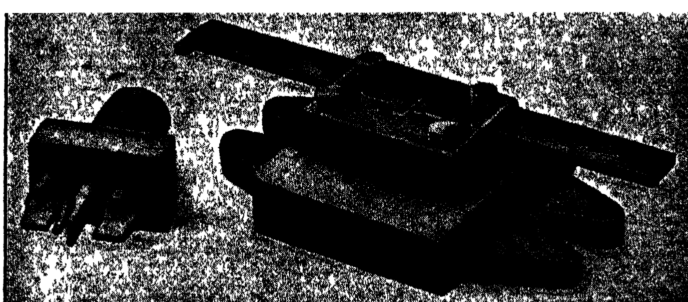


Fig. 146.—Slotting and cutting-off tools.

each end besides the round hole pierced at one end only. The ends are cut off square, and the work measures 7 in. in length. It is cut off from $\frac{1}{16}$-in. steel $\frac{1}{2}$ in. wide.

The punches are placed as represented in the plan and side views. The slotting punches are sheared along the edge to give free cutting action in piercing out the rectangular opening. They are placed $1\frac{3}{4}$ in. apart on centers, and the cut-off punch is located midway between.

The work is produced as indicated by the plan view of the die proper. The stock is first advanced past the cut-off punch which shears off the end of the strip, and the round hole *A* and slot *B* are pierced at the same

stroke. Then the work is fed along to the stop C, and the next down-stroke of the press pierces the slot D at the opposite end of the piece and also cuts the piece off at E and pierces hole A' and slot B' in the next length at the same time. So each following stroke of the press completes a piece.

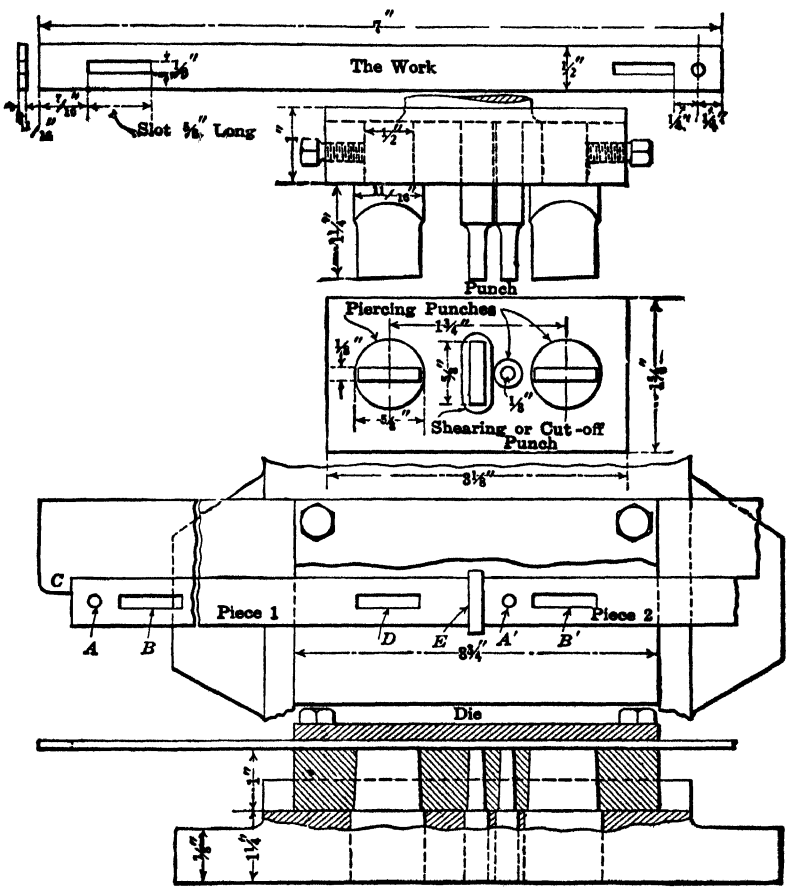


FIG. 147.—Slotting and cutting-off tools.

The stock guide under the stripper holds the stock closely sidewise and assures its being pierced and severed squarely without twisting to one side.

PARTING TOOLS FOR A GERMAN SILVER BAR

The set of dies in Figs. 148 and 149 are for cutting off german silver bars to form the decimal pointer bar used on a calculating machine. One of these pieces will be seen in front of the dies in Fig. 148, and detail dimensions are given in Fig. 150. The material from which the bars are

cut off is 0.140 in. wide and 0.078-in. thick. The ends are formed to a true half circle in the cutting-off process. The three small holes in the bar are afterward drilled and counter-sunk as shown.

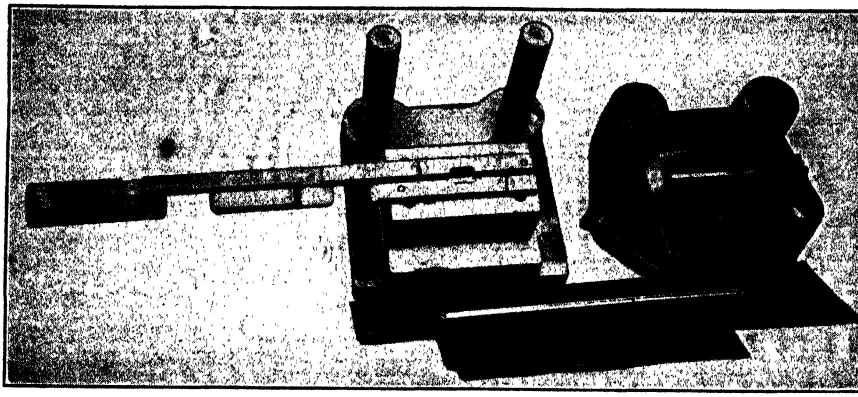


FIG. 148.—Parting and end-forming dies.

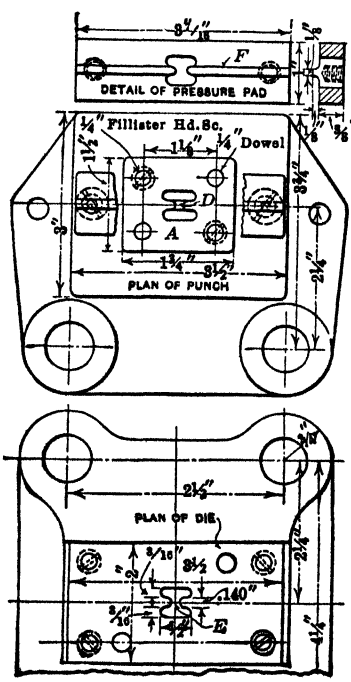


FIG. 149.

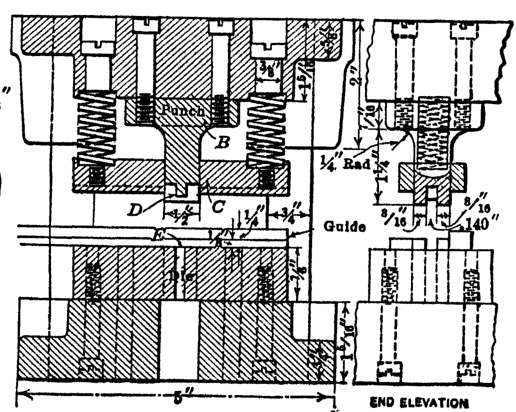


FIG. 150.

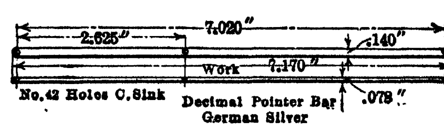


FIG. 151.

FIGS. 149–151.—Details of parting dies shown in Fig. 148.

The punch is in the form of a letter "H" as shown at *A*, Fig. 149, finished on the end of a square shank with broad base *B* secured by two fillister head screws and dowels to the head. This punch fits closely

through an opening in the pressure pad *C*, and the lower end of the punch is guided in the oblong die openings, while the central or cutting portion of the punch at *D* cuts the work apart and produces the rounded ends on the material. The small slug punched out to sever the work is forced down through the central die opening at *E* in the same manner as a slug from a piercing operation.

The narrow bar to be cut off is placed in the slot in the guide at the top of the die, this guide extending to the left as in Fig. 148 to support the projecting work and act as an end stop for determining the length cut off. This guide is attached to the die by two counter-sunk head screws, and its position is maintained by these screws and by a pair of small dowel pins.

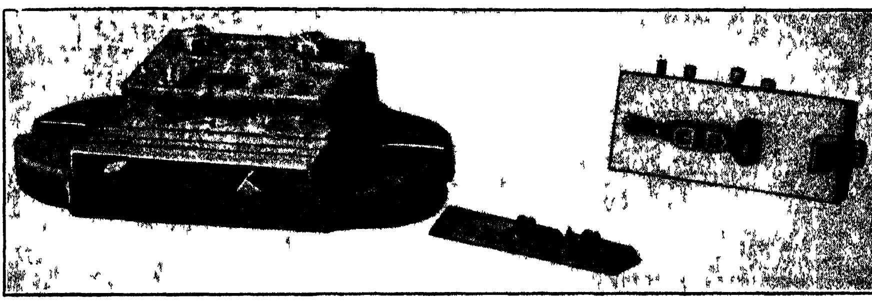


FIG. 152.—Progressive piercing, forming, and cutting-off dies.

The die itself is attached to its base by four fillister head screws tapped in at the corners from the bottom, and two dowels are located at diagonally opposite positions as seen in the photograph.

The pressure pad is formed with a central ledge or projection at *F* which bears directly upon the narrow strip of work during the cutting-off operation. This bearing surface extends the full width of the die face or $3\frac{1}{2}$ in., except for the one-eighth portion at the center which is cut out to clear the cutting portion of the punch.

PIERCING, FORMING, AND CUTTING OFF

The half tone, Fig. 152, illustrates a set of dies of the progressive order, for piercing, forming the lugs, and cutting off the piece shown in the foreground of the photograph. As represented the completed piece is shown resting in contact with a strip of metal pierced and formed for the lugs and ready for cutting off.

The tools are shown, also, in the line drawing, Fig. 153, and the work itself in Fig. 154. From the latter sketch it will be seen that the strip of steel is first pierced for the two holes *A*, *A*, which are $\frac{1}{8}$-in. diameter and $1\frac{1}{16}$ in. apart on centers; then the stock advances in the dies, and the two lugs or ears *B*, *B* are formed by a pair of piercing and bending punches,

and at the same time the triangular point C is formed down, and the corresponding point on the preceding piece formed at D. The third position of the work brings it into place for cutting off.

The order of operations is very clearly indicated in the sectional view, Fig. 155, where the two piercing punches are shown at A^1A^1 for the $\frac{1}{8}$-in. holes; the two cutting and forming punches at B^1B^1 for the lugs or ears B; the bending punches at C^1 for the pointed ears C and D; the cutting-off punch at E^1 for severing the finished work.

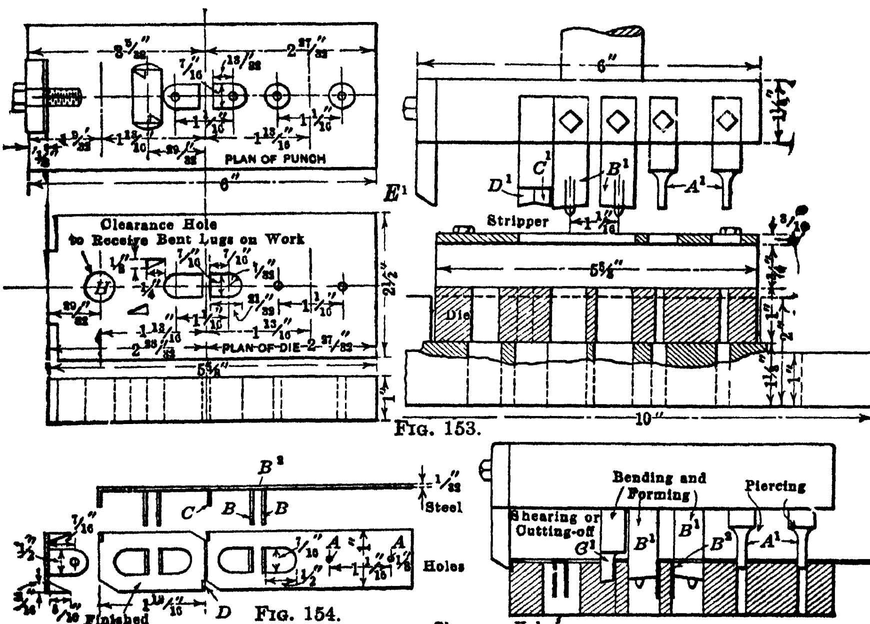


Fig. 153. Fig. 154. Fig. 155.

Figs. 153–155.—Piercing, forming and cutting-off tools.

The sectional views and plans in Fig. 153 show most of the important dimensions and the method of placing punches and other details. The punches B^1B^1 for cutting and bending down the projections or ears B are sheared or beveled from the rounded edge back to the heel so that the cut will be started at the semi-circular end of the ear, and the width of the punch back from this edge to the heel is $\frac{1}{32}$ in. under the dimension for the die or a difference equal to the thickness of the stock, so that the punch will have a bending action on the work and carry the material down over the corner as at B^2 and thus form up the lug as indicated. The punches B^1B^1 are provided with pilots to center the work from the two pierced holes put through by punches A^1A^1.

The punches C^1D^1 are sheared to cut from opposite corners to start the cut on the triangular points C; and as they have the same clearance of $\frac{1}{32}$

in. between the back of the punch and the edge of the die, they bend the point down in the manner shown.

The hole at *H* is a clearance space for the ears *BB* after these are formed and the material fed along for the next cut. The view in Fig. 155 shows the two projecting portions extending down into this opening. At the same time the two triangular points bent down at *C*, *D* pass over the end of the die at the left where the shearing punch cuts off the completed piece of work.

A number of other applications of cut-off or parting tools are shown in different sections of this volume, particularly in Chapter XIII dealing with forming and bending tools and methods.

CHAPTER V

CARBIDE DIES AND THEIR USES

One of the marked developments of recent years in the stamping of metal parts is the use of cemented carbide dies for certain classes of operations, including blanking and notching and trimming processes, as well as drawing operations in which the dies were first used as pressroom tools with the application of carbide inserts in shell drawing cases and the like where extremely accurate sizing was essential as well as highly finished surfaces on the work. In addition to these desirable results, greatly increased volume of product was also obtained before redressing of dies became necessary, and the total life of press tools was extended past all possible expectation. The broadening of cemented carbide die uses into such cutting work as blanking, trimming, etc., has been brought about through the activities of certain well-known manufacturers whose accomplishments in this particular field represent noteworthy progress in in the line of press-tool development. In short, the spectacular records made with hard carbide punches and dies equal in certain cases the well-known results attained in the machining of metal in lathe and boring mill and other metalworking equipment with the use of cemented carbide cutting tools, drills, and milling cutters. However, much less has been known heretofore about the great advances in pressroom operations under the influence of the cemented carbides when applied to properly designed punch press tools.

Increase in Die Life; Other Advantages

It is stated authoritatively that in many instances the life of cemented carbide punches and dies averages from 10 to 100 times that of steel press tools for the same purpose. Finish is superior, closer tolerances are maintained, usually greater speed is possible than with steel dies, and the dies are out of service far less time for maintenance and servicing. Ben C. Brosher,[1] reporting on this entire subject of cemented carbide punches and dies, states in the *American Machinist* that besides the successful use of cemented carbides for drawing dies for wire, tubing, and bar stock, compacting dies for powdered metals, and dies for cold swaging or pressure forming both solid and tubular metal products, carbides have been used successfully for cutting dies for piercing and blanking sheet metals

[1] Further data from the same author are given later on use of carbide drawing dies

and non-metallic materials, for punches and dies for drawing, tapering, or sizing cylindrical metal parts, and for forming dies for sheet metal. During the Second World War, carbide cold nosing dies, on high-explosive shells up to 105 mm., rated a production ranging from 1 to 3 million shells per die as compared with an average of about 50,000 shells for tool steel dies. In blanking, notching, and trimming dies, outstanding results have been obtained with carbides when the dies have been properly designed and the presses have been maintained so that punches and dies are kept in accurate alinement.

During the Second World War, for illustration, a metal goods company made radio-tube base parts from 0.0095 in. stainless steel, (30 per cent chrome) having a hardness of 87 Rockwell B. Punching, drawing, and trimming dies of conventional die steels required redressing every 50,000 or 60,000 parts. When cemented carbide inserts were used in a set of dies, more than 8 million tube bases were blanked, drawn, or trimmed without reworking the tools.

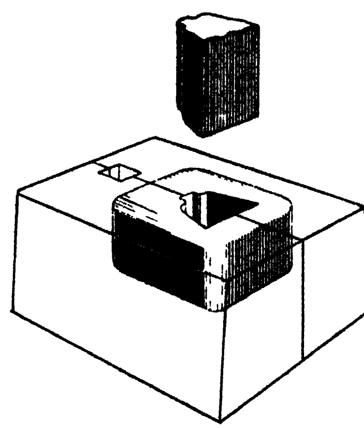


FIG. 156.—Laminated notching dies for indexing presses have greatly extended life when carbide inserts are used.

SILICON SHEET OPERATIONS

The General Electric Company has been using cemented carbide inserts in lamination dies for punching silicon sheet steels for several years. A striking example is the rotor lamination notching die in Fig. 156. Normally made of the best grade of high-carbon high-chrome tool steel these punch and die sets averaged about 150,000 slots between grinds. Application of carbide inserts in the split die and the use of a solid carbide punch has made it possible to run as many as 4 to 5 million slots before objectionable burrs are developed and the dies must be redressed before further production.

The author of the report, Brosher, quoted here in liberal abstract states that the O'Keefe and Merritt Manufacturing Company reports a fiftyfold increase in punch and die life together with elimination of burrs, with the use of a split cemented-carbide stator lamination punch and die set made of solid carbide.

In both types, die blocks are designed to be clamped between key or matrix blocks on the die shoe. They are sharpened by grinding metal off the top and relieving each half of the die to maintain the correct size. Only the sides of the dies have clearance; the ends are straight. The

face of the solid carbide punch is concave, giving it a shearing action and reducing the load on the punch.

The O'Keefe and Merritt die is used for piercing lamination disks 0.016 to 0.018 in. thick having a 2.50 per cent silicon and 0.12 per cent carbon content. Before piercing, the steel is heat-treated to produce a tight scale which has valuable insulation properties, but which materially increases the abrasiveness of the stock.

Some Piercing Records

Piercing is done without lubricants in an indexing press operating up to 600 strokes per minute. Production records show conventional steel dies lasted for about 46,000 hits between grinds. Cemented-carbide dies now last for 1,600,000 to more than 2,300,000 hits before redressing is necessary. None of the carbide dies in use at this plant have as yet worn out, so total life cannot be computed.

Sylvania Electric Products has been using tungsten-carbide parts in press dies for several years, and from 50 to 75 per cent of the dies constructed include carbide parts. Dies are used to pierce or form 0.005-in. thick stock and are made to close tolerances. The punch must be kept aligned exactly with the die elements. Poor alinement causes the cutting edges to chip almost immediately.

Clamping Carbide in Place

Sylvania tool engineers claim that clamping the carbide elements in place is superior to brazing the carbide to the steel, but in all too many cases brazing is necessary for holding tips in place. Brazed tips usually are satisfactory only when punching thin stock, as for radio-tube parts, but the brazed joints break down rapidly when heavier stock is punched, permitting the carbide pieces to loosen and shift or fall off.

The increased speeds which are obtained and the long life which is possible with carbide dies, coupled with reduction of labor and of time lost in maintenance and servicing operations, are of great importance. Of course material and labor costs of building the carbide tools is greater than with steel.

A Four-punch Notching Die

The notching die, Fig. 157, built by Sylvania for use on a multi-slide forming machine has a solid carbide die insert which is held in place between two steel clamp blocks which also serve as guides for the four carbide-tipped notching punches. The carbide die insert has two 0.156-in.-diameter lapped holes to clear two spring-loaded pressure pins which extend vertically through the die assembly to hold the strip stock

slightly above the carbide insert while the stock is being fed through the dies between strokes.

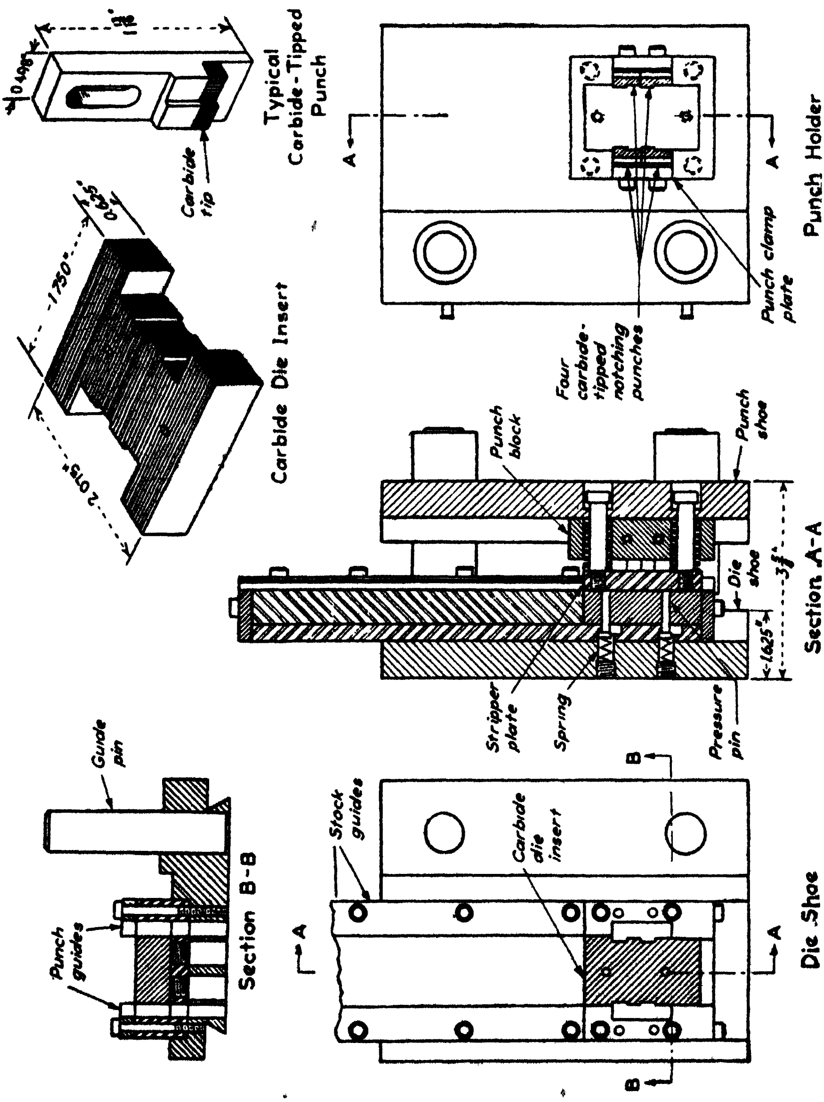


FIG. 157.—This Sylvania die for notching 0.005-in.-thick strip in a multi-slide machine, has a solid carbide die block clamped in place on the die shoe and four carbide-tipped notching punches adjustably mounted in the punch assembly.

PUNCHES ARE PROPERLY GUIDED

Each punch is made of tool steel, hardened to 62-63 Rockwell C and ground all over. The carbide tip is brazed to the punch. The punch shanks have a lip extending approximately $\frac{1}{8}$ in. below the carbide tip so that the punch will be engaged in its guide slot before the carbide strikes

the work. Each punch is slotted for vertical adjustment on the punch block. Under the block is mounted a heavy, spring-loaded stripper plate carried on two large die screws. Accurate alinement of punches with die insert is ensured by means of large guide posts in the die shoe which enter bushings in the punch head.

As some indication of the small sizes of carbide piercing punches which are practicable for use, reference may be made briefly to a progressive die which is described as having nine pieces of cemented carbide, each silver soldered onto a punch or die member. The die set is used for notching, piercing, and forming top shields for a radio tube. The small piercing punch is 0.092 in. diameter, and has a $\frac{1}{8}$-in. long carbide tip silver soldered

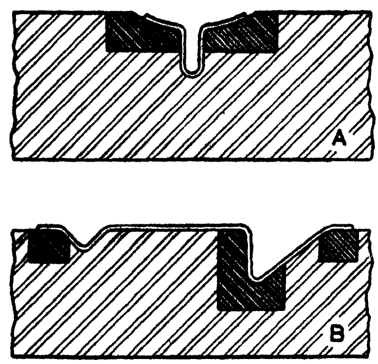


FIG 158 —Carbide inserts for forming dies.

on for a cutting surface. The tool-steel punch is 1 $\frac{17}{32}$ in. long, hardened to 55-58 Rockwell C and ground all over before tipping. The 0.092-in. tip is fitted to a carbide piercing die insert in the die block within plus 0.0000, minus 0.0002 inch. Punch and die have to be perfectly alined.

A Razor Blade Die Set

A die set made by Barth Stamping & Machine Works to pierce and notch razor blades from 0.004-in.-wide strip steel in a soft state incorporates 41 pieces of cemented carbide. There are two notching punches, the center contour punch, two rectangular pilot pins, and four shaped die blocks, all of solid carbide. Other carbide members in the set include stock guides, guide-post bushings, and wear strip inserts for the guide posts. At the time the article was written, the die had pierced and notched almost 2 million blanks without resharpening, and no appreciable increase was found in the burr condition (estimated at about 0.0002 in.) although typical steel dies for the same work usually required redressing after each 100,000 or 125,000 blanks.

It need not be expected, even with the great advance in the use of carbide dies, that they can be applied to every set of dies. Each appli-

cation is to be studied as a special case in order to find its suitability for one or another grade of carbide material and for justification of the higher cost of carbide dies. It is stated that so far the best results have been obtained when blanking or piercing steels and other materials in thicknesses under about 0.025 in.; although experimental work is being done in the development of stronger, tougher, and more shock-resistant carbide materials to adapt them to more severe blanking and piercing operations up to approximately $\frac{3}{8}$-in. plate.

Form Dies

The General Electric Company states that forming dies with cemented carbide inserts, as in Fig. 158, show much longer life—say seven times that of ordinary dies—when wear points are made of inserts of carbide and stainless steel is being formed. While good results are obtained with the simple form die at *A*, savings are more spectacular in more complicated forming dies as at *B*, Fig. 158. Usually these forming inserts are brazed.

Section II

COMPOUND DIES AND OTHER CUTTING DIES

CHAPTER VI

PRINCIPLES OF COMPOUND DIE CONSTRUCTION

The compound die in its simplest design is adapted for producing at a single stage a pierced and blanked article, say a common washer, with outside diameter and hole diameter to any desired dimensions. Or holes of any shape and number may be pierced in a blank of any desired contour, and the blank itself produced at the same stroke that performs the piercing operation.

The compound die action is such that its product is very accurate, and a die made correctly will do correct work throughout its working life. Usually it is more expensive to construct than the plain die of two-stage design, which is the simplest of progressive types of press tools. However, on long press runs, its first cost is more than justified, and on certain classes of accurate work it obviates the necessity for shaving operations, especially in some instances where the pierced holes must bear a precise relationship to a particular portion of the outside of the blank.

While originally adopted for small circular blanks, of the type of small toothed wheels, special washer-shaped parts, pierced instrument elements, and the like, it later appeared in large designs for almost every kind of work where its application might be advantageous economically or mechanically. A typical illustration of its use on larger parts is for punching out parts for electric motors. Dies for armature disks are frequently made up of many individual members.

The usual arrangement of compound punch and die is to locate the blanking punch on the die shoe and the blanking die on the punch head so that the piercing punches are fitted in the blanking die above and the piercing dies are drilled or formed in the blanking punch below. There are occasions where this inverted position of punch and die is not adhered to in compound die construction. There may be a variety of reasons for such practice, as for example where there is no knock-out for the upper die; or, owing to the size of work and die, it may not be feasible to introduce a knock-out into the upper die shank. In such case, with the punch above, the slug openings in the punch provide for passage of the pierced slugs out of the tools. Ordinarily with the punch fitted below to the die shoe, the piercings—or slugs—pass down through the die shoe as with a plain piercing die.

With the usual inverted arrangement of compound die details, the blank is forced up into the die attached to the punch head and is ejected by either a spring-actuated knock-out or a positive knock-out according to the general type of press used for the work. For ordinary sizes and classes of work the spring knock-out is applied satisfactorily and is usually mounted inside the shank of the punch head. For larger blanks a centrally applied knock-out spring is not adequate, and it is more general practice to use a series of short springs against a shedder or knock-

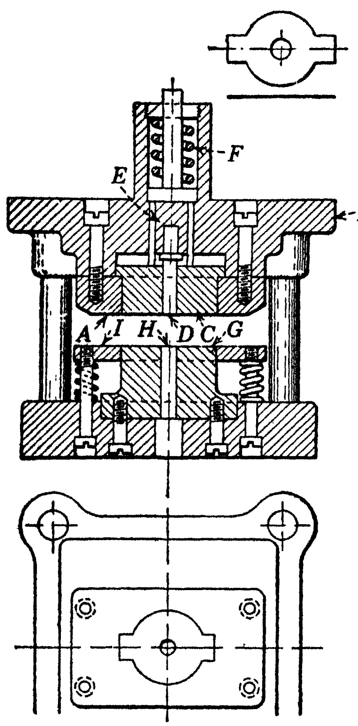


Fig. 1.—Compound die construction.

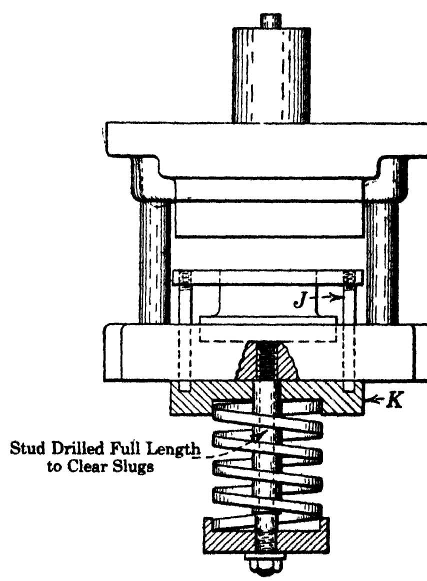


Fig. 2.—Pressure springs under compound die.

out plate with the springs housed in suitable counter-bored seats in the lower face of the punch head itself. In this case, whether the punch head has a shank or not, there are no parts of the spring knock-out projecting above the upper face of the punch head.

The blanking punch, mounted on the die shoe, is enclosed in a stripper which clears the scrap from the blanking punch upon the up-stroke of the press. The stripper is actuated by springs in the die shoe or by a rubber "barrel" or cushion underneath, which acts as a spring; or there may be a spring pressure plate mounted under the bolster which acts against stripper pins extending down through the die shoe from the underside

of the stripper to the surface of the spring pressure plate below. This carries the scrap strip up with the motion of the press and strips it clear of the blanking punch, the top face of the stripper rising flush with the top face of the punch.

The piercing punch which is secured in the punch head knocks the slug down into the piercing die hole formed in the blanking punch carried by the die shoe. As in the case of plain piercing dies, the slug hole is cleared well below the die surface to allow freedom of movement of the slugs down and out of the dies.

The stripper plate for the blanking punch serves as a pressure pad for holding the stock snugly and smoothly between die face and stripper. With the action of the spring shedder or ejector for the blanking die, the blank, as the die rises, can be carried back into its opening in the scrap and thus carried out of the dies by the forward feeding of the material.

A Typical Arrangement

With reference to Fig. 1, which illustrates a die set constructed with guide posts for alinement of punch and die, a characteristic design of compound die is shown in assembled form. The pierced blank produced with these tools is shown at the top of the drawing. The blanking die *A* is attached by fillister head screws and dowels to the punch head *B* and is fitted with the shedder or ejector *C* which also fits the piercing punch *D* housed in the die shoe. Pressure pins *E* acted upon by spring *F* in the shank keep the ejector normally flush with the lower face of the blanking die *A*, except when forced upward by the blanking operation when the punch head is closed on the work by the down-stroke of the press.

The blanking punch *G*, here shown with a flanged base, is formed with the piercing die opening in the center at *H* and is provided with the close-fitting stripper plate and pressure pad *I* which is mounted upon a series of compression springs carried by the guide screws in the corners of the stripper plate. When the upper die descends upon the strip of stock, the blank is forced up against the action of the shedder *C* and snapped out into the die, and at the same time the piercing punch knocks out the slug into the die opening *H* which is tapered to the usual degree and cleared for passage of the successive slugs down and out of the press.

On the up-stroke the shedder *C* of course clears the blank out of the die *A* through the action of the pressure springs above. On some work, particularly on heavier gages of stock, the positive knock-out on the press is applied to shedding the work from the blanking die.

There are a number of ways of mounting the stripper springs and plate *G* and also different arrangements of the shedder or ejector in the blanking die *A*, according to the class and size of work to be produced

in the dies. Usually the pressure applied between stripper I and punch face A is sufficient to prevent buckling or wrinkling of the work and strip of material.

Reference has been made to the use of a rubber "spring" or a single coiled spring below the dies for operating the stripper plate for the blanking punch G.

One or the other of these devices is used very commonly in press shops. Not infrequently the underside of the bolster is equipped with a permanent pressure spring attachment which is applicable to many different sets of dies of the type discussed here. In such instances the pressure pins which operate the stripper for the lower blanking punch are extended downward far enough to come in contact with the upper face of the spring plate under the press bolster.

The sketch, Fig. 2, shows a method of using a single heavy spring secured to the under side of the die shoe itself. The pressure pins J for actuating the stripper are housed at their lower ends in seats in the top of pressure plate K, and the spring below is confined between this plate and the disk on the lower end of the stud screwed into the die shoe. Adjustment for pressure is possible by means of the nut on the end of the stud.

The stud is drilled longitudinally to provide a clearance opening, through which the slugs from the piercing punch are discharged out of the dies.

Tools for a Thin Disk

A set of compound tools for producing a brass disk from No. 20 gage metal is shown in Fig. 3. The diameter of the blank is $1\frac{1}{8}$ in., and the two holes pierced at opposite sides on the center line are 0.10 in. in diameter. These compound tools illustrate a case where the blanking die is mounted on the shoe and the punch carried by the punch head.

The blanking punch is shown at A, Fig. 3, and the blanking die at B. Piercing punches are located at C, and the piercing die holes at D where they are drilled out and finished in the blanking punch. The blanking die B is provided with an ejector or knock-out, which is drilled and counter-bored from the underside to carry the piercing punches C. The blanking die measures $1\frac{1}{4}$ in. across the diameter which is finished with a shoulder to correspond with the internal shoulder of a clamping ring E. The clamping ring not only houses in all of the parts of the lower die but also serves as a locating means in the die base, as it is fitted into a shallow seat bored into the face of the base and is there located and secured by two dowel pins and four fillister head screws. These screws are tapped in from the underside of the die ring.

Blanking die *B* rests upon the chambered ring *F* which fits the bore of the retaining ring or housing *E* and is recessed out to a diameter sufficient to receive the flanged base of the ejector or knock-out *G*. This is a nice sliding fit in the die, and it serves as a guide for the slender piercing punches *C*. The latter are made with enlarged bodies and heads and are

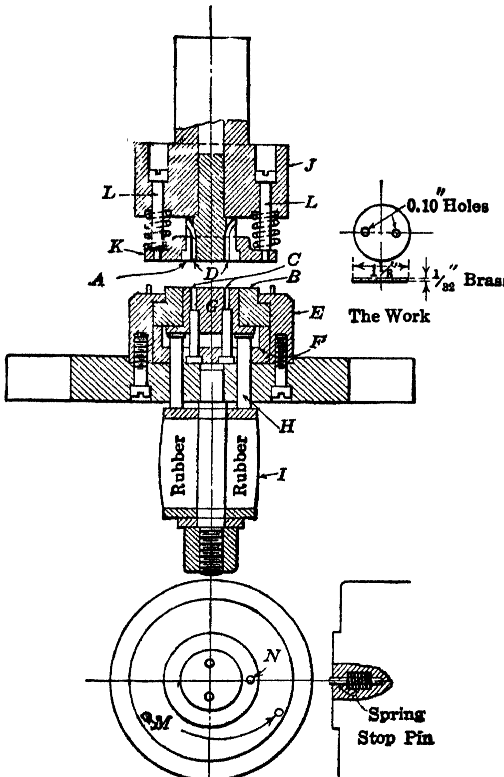


FIG. 3.—Details of compound die.

secured by being let in from the underside of the ring *F* which is counterbored to conform to the dimensions of the heads of the punches.

Operation of Knock-out

The knock-out is normally held in uppermost position as indicated by the pins *H* and the rubber spring *I*, the latter being retained between two steel plates and the whole unit of rubber, washers, and carrying stud being easily removable at any time. It is the practice in many places to make one or two of these rubber shedder outfits do duty with a number of different sets of dies as required. The device is attached to any set going into the press and is removed and transferred to another pair of

dies when the first job is completed. This simplifies the making of the tools in the first place, and where any given set of dies is used only occasionally a considerable measure of economy is effected.

While the dies in Fig. 3 are shown with the rubber form of spring, such tools, as stated, are very commonly made with steel compression springs of various sections which are used for operating the shedders and knock-outs. Some die-makers prefer the steel spring, and others the rubber. Each has advantages, and very often the question of limitation of space in the tools or press determines the spring medium that shall be employed.

Where space is available it is desirable to make the ejector pins *H* with small heads in order that they may not fall out when the rubber or spring device at the bottom is removed.

Blanking Punch Details

The blanking punch *A* is secured in the holder *J* and is enclosed in the shedder ring or stripper ring *K* which is normally forced down to the lower position shown by the action of the pressure springs on the fillister head screws *L*. The two openings constituting the piercing dies are drilled in the blanking punch, and at their upper ends two holes are drilled in at an angle to form a passage out of the punch for the slugs as pierced out of the blank by punches *C* below.

Two guide pins for the strip of stock are located at *M*, and a stop gage at *N*, as seen in the detail sketch below the die. The stop *N* is spring actuated, and when the punch descends the combined pressure pad for the stock and stripper *K* forces the pin downward. The blanking punch, continuing to descend, blanks out the disk in die *B*, and the two piercing punches *C* pierce the small holes, the blanking punch forcing the shedder *G* downward against the action of the rubber below. Upon the up-stroke the shedder *G* rises, clearing the blanked and pierced disk from the blanking die and piercing punches, and at the same time the stripper *K* strips the stock from the blanking punch *A*.

It should be noted that the small die holes *D* in the blanking punch are originally drilled and reamed all the way through the blanking punch to enable the holes to be taper reamed from the top to an angle of 2½ degrees for clearance for the slugs. Afterward the tops of the small die holes are plugged as indicated, and the passage of the slugs deflected by the side openings at an angle in the die. The punches *A* and *C* and die *B* are of tool steel hardened.

A Contrast in Construction

The work pierced and blanked, in the dies, Fig. 4, is about 4 in. long by 1 in. wide. The hole pierced is ⅜-in. diameter.

This compound die is made up as shown by the drawing. The blanking punch *A* is here inverted and carried by the lower shoe *B* to which it is secured by fillister head screws and dowels. It is provided with a spring-actuated stripper plate *C* which is forced upward by the

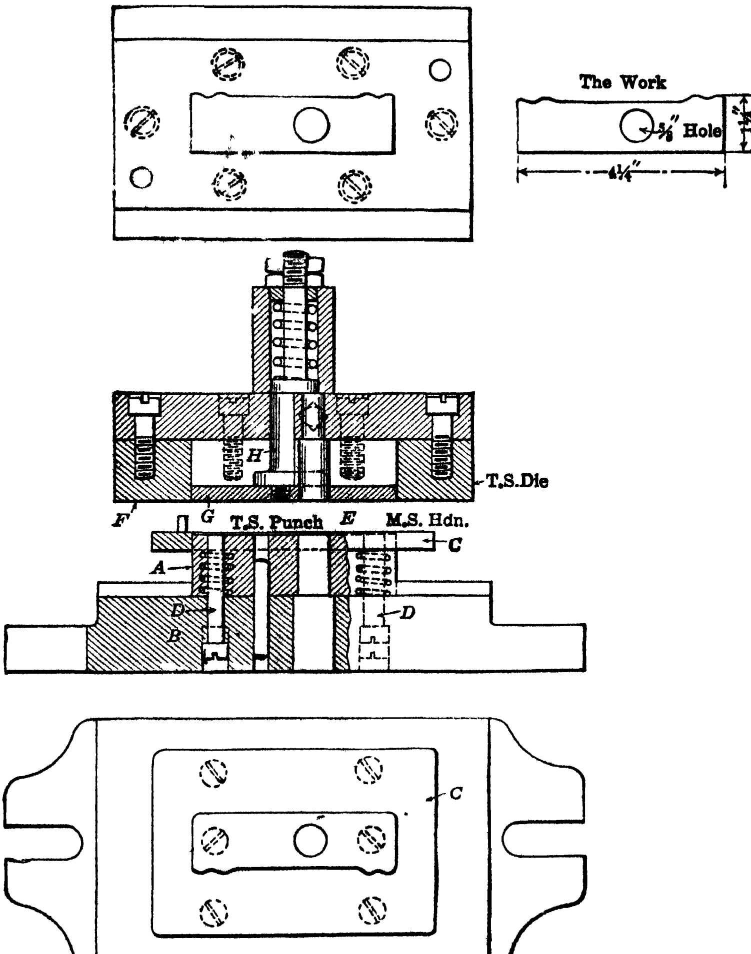


Fig. 4.—Construction of compound die.

compression springs on the four screws *D*. This stripper plate carries the gage pins for locating the stock.

The piercing die is formed in the blanking punch, and the piercing punch *E* and blanking die *F* are carried by the upper head, the parts being secured as shown. The blanking die is provided with the knock-out *G* which is carried by the spring plunger *H*. The work blanked is quite

thin, and the spring knock-out is therefore sufficiently stiff to answer the purpose for which it is intended.

It will be seen that the work pierced and blanked in a compound die of this type is handled under several advantages as compared with the progressive type of tools. In the first place the blanking and piercing being accomplished simultaneously, accuracy of the hole position is assured in respect to the edges of the blank. As the stock is held between the pressure pad and the face of the die, and the blank as produced is supported by the knock-out in the die, the work is necessarily kept flat and free from wrinkles and distortion. The piece of work produced in the dies shown is, of course, of a simple character, but as we proceed with other examples of compound die work we shall find some more intricate constructions.

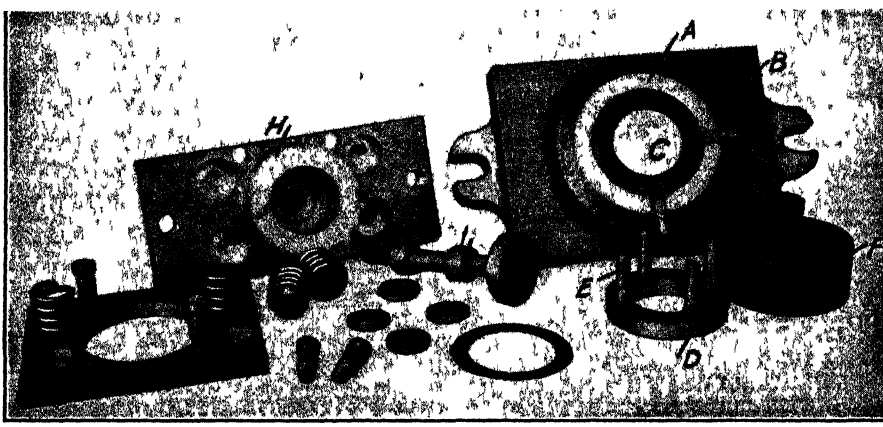


FIG. 5.—Showing details of tools in Fig. 6.

MAKING A THIN STEEL RING

In Fig 5 a set of tools taken apart are shown for making a steel washer of light-gage stock. The outside diameter of the work is 3 in.; the hole blanked out at the center is 2 in. The dies are of the compound order, and the details of the different parts will be seen in Figs. 5 and 6.

The tool steel blanking die A is secured in the cast shoe B, and the tool steel piercing punch C is located concentric with the die and pressed snugly into place in its seat. The ejector ring D is made to fit in the annular space between the die and punch, and this member is fitted with four operating pins E whose bodies pass down through the base and rest upon the rubber attachment at F which is made up of a pair of $\frac{1}{4}$-in. steel plates with the rubber section between. The attachment to the base is by means of the $\frac{3}{4}$-in. shouldered stud which is tapped into the casting.

The blanking punch *H* of tool steel is bored out to form the piercing die and to admit the knock-out *K* which has a shank passing up through the punch holder with two check nuts at the top. For light stock a rubber spring or a steel coil spring at *I* may be made to serve the purpose of ejecting the center as punched out of the work by the piercing punch. With the extended shank on the knock-out a positive action may be secured by

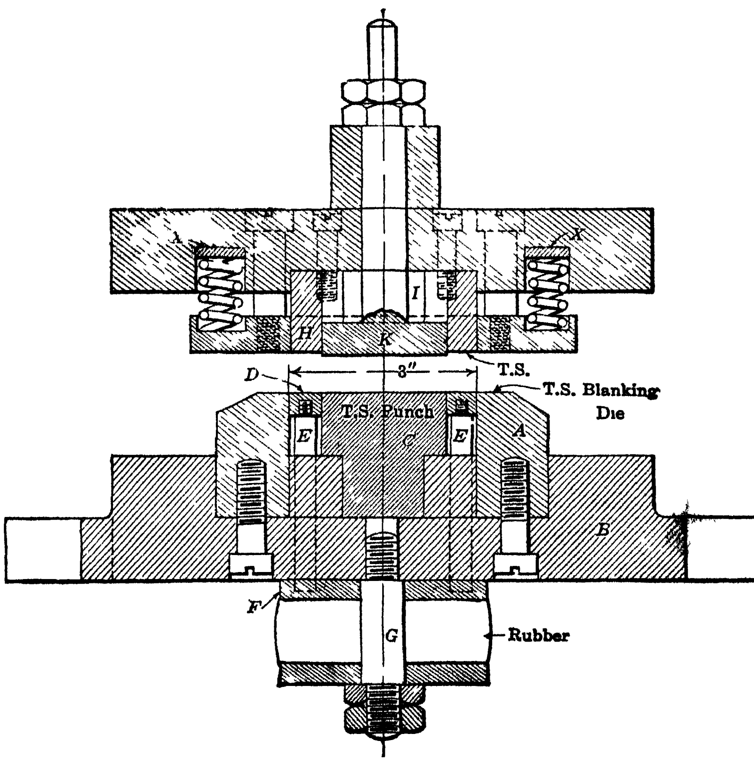


Fig. 6.—Sectional view of the dies in Fig. 5.

the top of the shank on *K* striking a stop on the press guide when the ram ascends to the top of its stroke.

Positive Knock-out

One form of positive knock-out is that shown by the sketch, Fig. 7. The horizontal bar *L* passed through a slot crosswise of the press slide is suspended by springs at the end and is adapted to rest with its upper surface against the top of the slot. When the ram is near the top of its stroke the top of the knock-out bar *L* contacts with the two adjustable stop screws *M* carried by the press guide, and as the bar *L* can then travel upward no farther, the result is that the ram continuing upward forces

the top of the knock-out plunger N against bar L, and the slug is ejected from the upper die O.

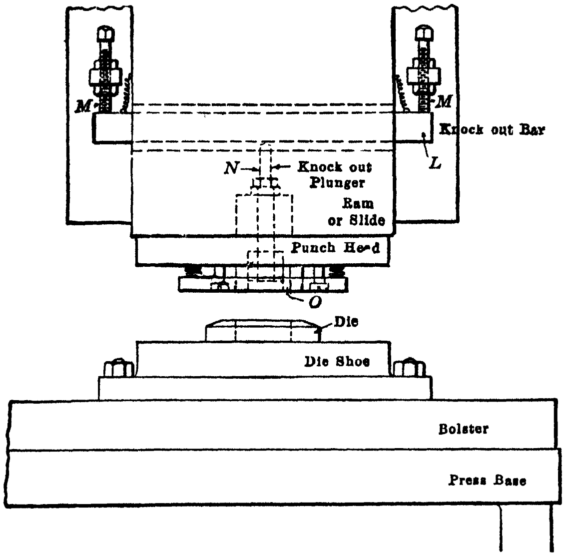


FIG. 7.—Application of positive "knock-out."

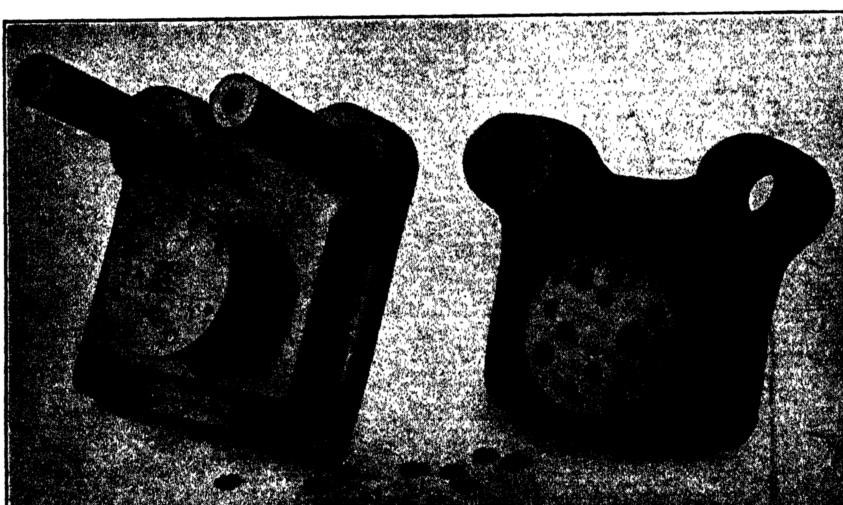


FIG. 8.—Compound dies for making a small gear.

A SMALL GEAR WHEEL JOB

The photograph, Fig. 8, illustrates another form of compound die as applied to the blanking and piercing of a small nine-toothed gear which is

made from $\frac{1}{16}$-in. sheet steel. The gear is $\frac{9}{16}$-in. outside diameter, and the hole at the center is $\frac{1}{8}$-in. diameter.

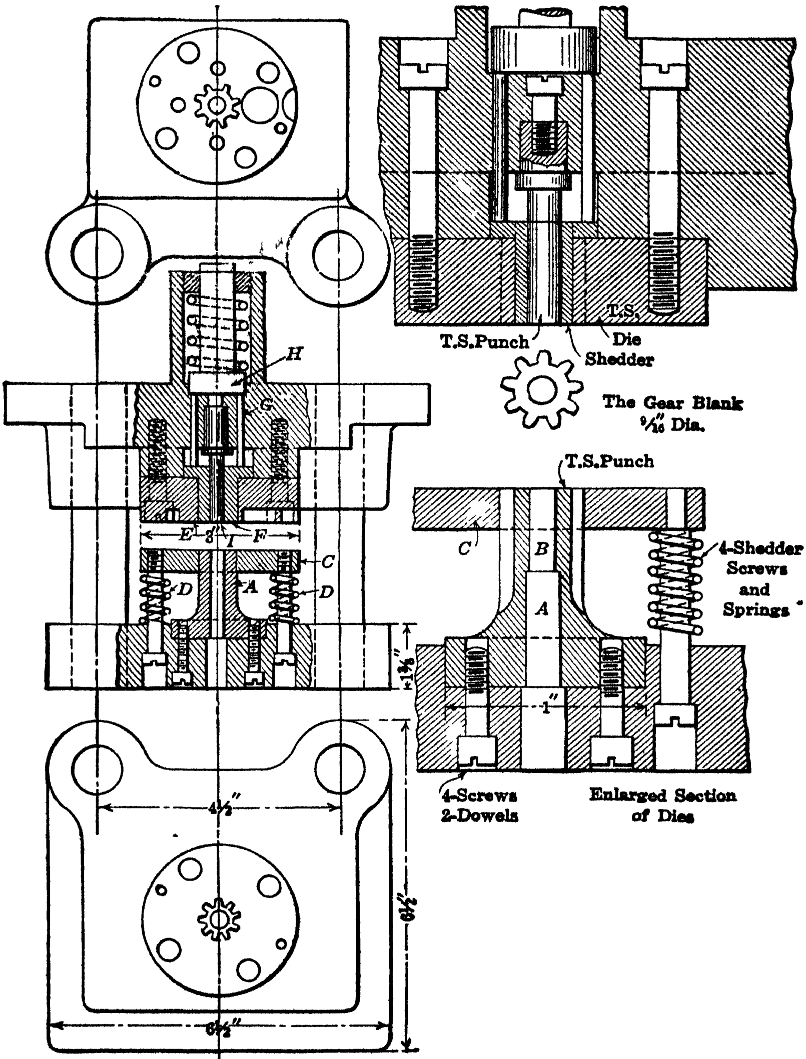


FIG. 9.—Compound dies for making a small gear.

The tools are of the sub-pressed type with two pillars at the back of die shoe and punch head. The details of construction are covered in the line engraving, Fig. 9.

The blanking punch is located at *A* in the lower member of the set. The hole *B* at the center of this punch for the piercing die is relieved a short distance below the top, as seen more clearly in the enlarged detail in

this engraving, in order to clear the slugs more freely. The punch body *A* is let into the cast base and secured by screws and dowels. It is fitted with a stripper plate *C* which is made to the same tooth outline as the punch and is actuated by the four pressure springs beneath at *D*.

The blanking die *E* is inverted and carried in the upper member of the set of tools. It is here secured in the same manner as the blanking punch *A* below and is bored out to receive the ejector *F* which is held in lower position by four small knock-out pins *G* which pass up through the head and come in contact with the spring-actuated plunger *H* at the top.

Action of the Tools

The piercing punch *I* fits through the center hole bored in the ejector and is formed with a shouldered shank fitted in the head as indicated. When the press slide descends the gear is blanked out in die *E* by punch *A*, and at the same time piercing punch *I* forms the center hole by punching the slug into the piercing die in punch *A*. When the dies separate by the up-stroke of the press stripper *C* clears the blanking punch *A* of the stock scrap, and the knock-out *F* ejects the work from the blanking die *E*. The slug from the piercing operation passes down through the die opening in *A*.

The punches and dies are of course of tool steel properly hardened, and the knock-out pins *G* are of drill rod. The stripper and pressure plate *C* carries the stops and locating pins which serve as a gage for the stock. The die *E* at the top is counter-bored at two points on the center line to provide clearance openings for the gear blank as carried along through the dies by the movement of the strip of stock as it is fed forward for the production of successive gears. The gear as produced and knocked out of the blanking die is forced back into its place in the scrap by the action of the ejector or knock-out *F* and is thus carried along with the material as it feeds along between the dies.

The special feature of dies of this character, where the work is ejected by the process shown and forced back into the opening in the scrap, has led to their being called in some places "cut-and-carry" dies.

Washer and Key Slot Dies

The compound tools in Figs. 10 and 11 are for making a thin washer or ring in which a key slot is pierced at the same time that the outside is blanked and the center punched out.

The view in Fig. 11 of the tools taken apart shows all of the members clearly, and it is unnecessary here to enter into a prolonged description. It may be pointed out that the piercing punch is made up with a square extension at one side for producing the key way cut and that similarly the interior of the blanking die is cut out for a key slot to correspond. Also the knock-out for both tools is made with the key slot in the blanking die

ejector and with the key extension on the side of the knock-out in the piercing die.

The shedder springs and the rubber knock-out device for the lower die are identical with the others already described. There is one further

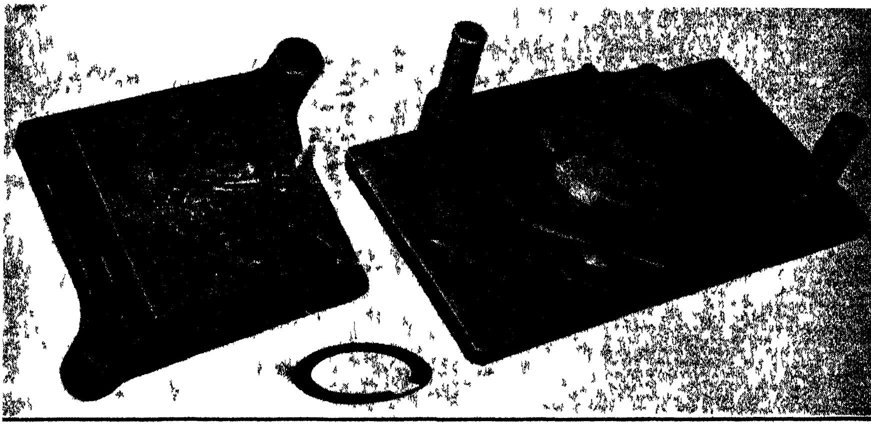


FIG 10.—Dies for thin washer with key way punched out

feature that should be noted here. This is the set of disks seen at the right of the stripper plate which are adapted to fit into the counter-bored seats for the ends of the compression springs which operate the stripper on the blanking punch. These disks are $\frac{1}{8}$ in. thick, and their purpose is

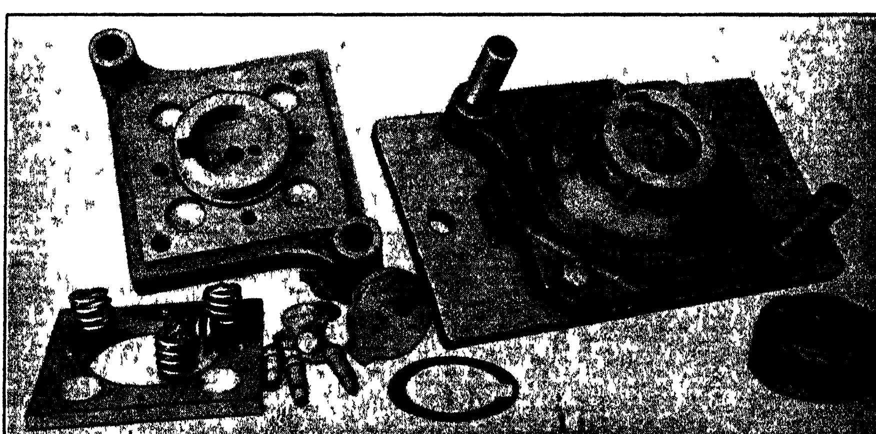


FIG. 11.—Showing construction of dies in Fig. 10.

to diminish the depth of the spring seats by that amount when the dies are new. After repeated grindings have shortened the dies by about the same degree or $\frac{1}{8}$ in., and the stripper has been adjusted accordingly, the disks are removed so that the springs then have practically the same

distance between their opposing seats as they had at the outset, thus keeping a fairly uniform tension during the continued use of the dies.

Larger Compound Tools

Still another interesting set of compound dies is shown by Figs 12 and 13. These are for making a disk of steel plate about $\frac{1}{16}$ in. thick, having a large V-gap cut at one side and two rivet holes pierced along each edge of the gap. The center is punched out at the same time. General proportions of the work are indicated in Fig 14, and a good idea of the principal features of the dies themselves is presented by the plan and sectional views in Figs 13 and 15

Fig 12 —The dies taken apart.

The work is a circular blank about 6 in. across, and the V at the side is about 30 degrees included angle. The piece is seen to the left of the group of die parts in Fig. 12. The blanking die is shown at *A*, and the blanking punch at *B*. The blanking die head is bored at the center for a seat for the piercing punch *C*, and both the punch and the internal wall of the blanking die are slotted as indicated at *D* to receive the ends of the inserted piece *D* which blanks out the V-shaped opening in the disk.

The blanking punch is bored and ground out at the center for a 2-in. hole *E* to form the piercing die. The punches and the die are of tool steel carefully hardened and finished and secured by fillister head screws and dowel pins to their respective holders.

Stripper and Knock-out

The stripper and pressure pad which encloses the blanking punch *B* is operated as at *F* against a thick rubber ring *G* which is seated in a large recess faced out in the shoe *H*. A series of fillister head screws passing up through the ring and into the stripper retain the latter in position.

The knock-out disk *I* for the blanking die is held by screws from the top of the head and is actuated by a series of stiff springs to eject the work

from the die when the latter rises from the punch. The four small rivet hole piercing punches *JJ* are inserted in blocks which are fastened by

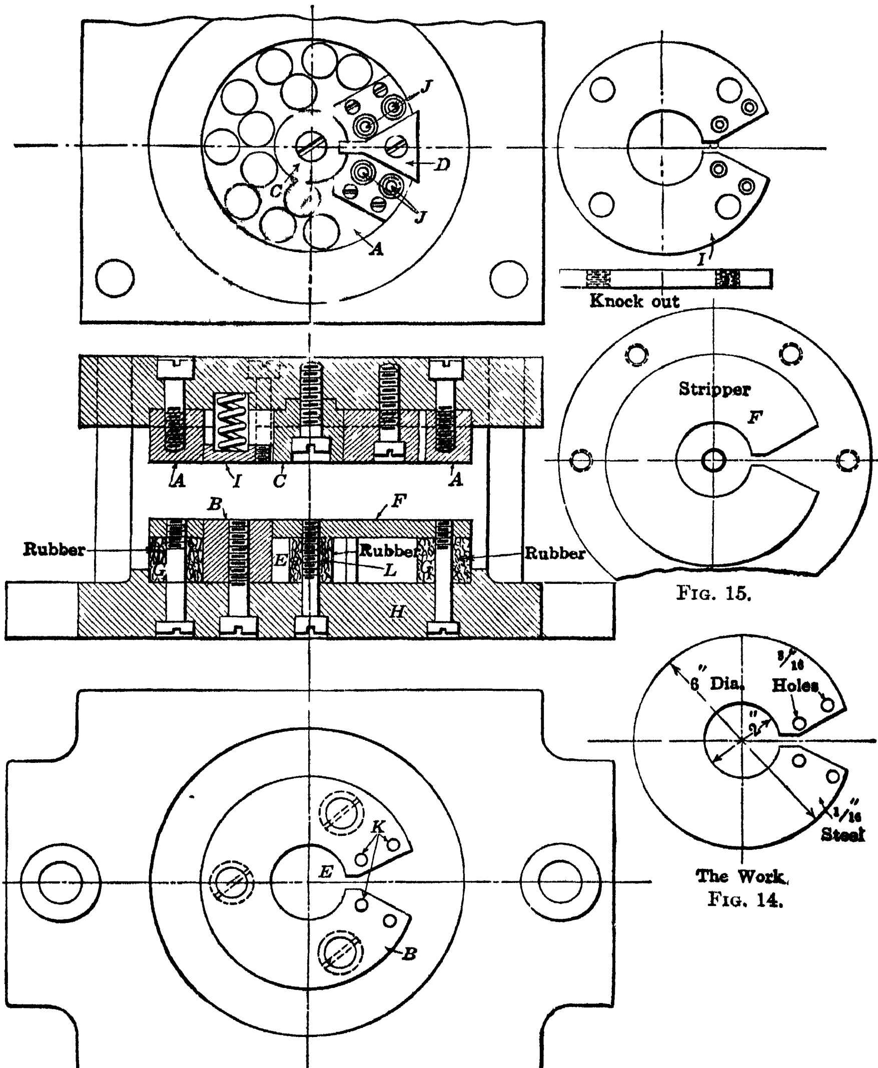


FIG. 15.

FIG. 14.

FIG. 13.

FIGS. 13–15.—Construction of dies shown in Fig. 12.

screws and dowels in the interior of the blanking die as seen in the drawing. These small punches and their holding blocks are also shown in place in the die in Fig. 12.

The die holes for the piercing of the small holes are shown at *KK* Fig. 13, and the corresponding holes in the knock-out *I* are plainly visible in the photograph, Fig. 12.

Both the stripper *F* and the knock-out *I* are shown by detail sketches in Fig. 15. The central portion of the stripper is attached to the main ring by a narrow tongue as indicated, following, of course, the outline of the piercing punch at this point. The projecting portion of the stripper is therefore provided with a separate rubber spring at *L*, and a fillister head screw is tapped in from the underside as with the other portions of the stripper ring.

A Rectangular Piece of Work

Another large compound die is represented by Fig. 16. The tools here are for producing the steel plate in Fig. 17 which is afterward bent and formed to the shape in Fig 18 for a casing for certain mechanism of a coin register. The stock is $\frac{1}{16}$ in. thick, and the piece is cut out approximately to length and width before it is placed in the compound dies for trimming to correct shape and piercing of the various holes.

There are a number of different sizes of holes among the number pierced, and some of them are rectangular for the staking in of other members. The largest round holes are 1.082 in. in diameter, the smallest 0.125 in. Four small tongues are formed along one edge in these dies and the $4\frac{5}{8}$-in. gap at the front is also cut out.

The half-tone engraving of the tools gives a pretty clear conception of the manner in which the dies are made up. They are of sectional construction, the blanking die *A* being built up of tool steel sections let into channels planed in the base and there held by fillister head screws and dowels. The piercing punches are inserted into place in the die base, and the larger ones held by a screw from the bottom. The smaller ones are pressed into their holes.

The blanking punch with its openings constituting the piercing dies is seen at *B*. This member is also sectional, and the locations of holding screws and dowel pins will be noticed in the view. The stripper for the punch is shown immediately in the front of that member, and the knock-out for the blanking die *A* is likewise seen in front of the die base. Both knock-out and stripper are bottom side up in order that the provision for operating springs may be visible.

For the die knock-out there are 15 of these springs; for the punch stripper there are 12 in all. The seats for the ends of the springs are neatly formed by hollow milling in a series of annular channels which are $\frac{1}{8}$ in. deep and of the proper diameter outside and inside to accommodate the spring dimensions. This gives a form of spring seat that holds the spring without possibility of its tilting and thus maintains it in most effective position at all times.

The underside of the stripper is shown fitted with four flat springs. These act upon the lower ends of a set of gage pins or stops which normally

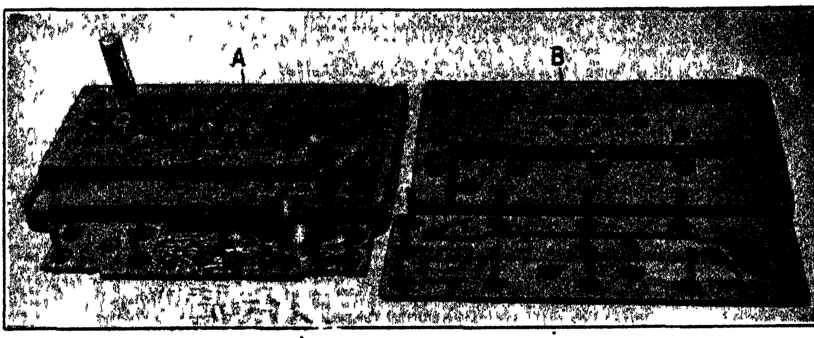
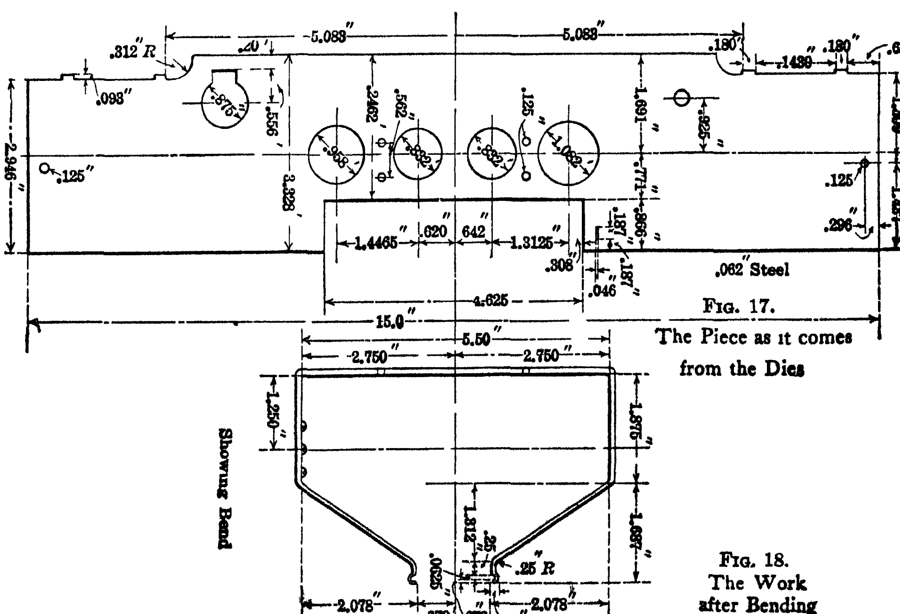


FIG. 16.—Large compound dies for blanking and piercing a rectangular plate.

extend up through the face of the stripper and form setting stops for the work. Upon the punch passing down into the work, the spring pins are depressed accordingly and rise to original position when the punch again ascends.



FIGS. 17–18.—The work blanked and pierced in large compound die.

ELECTRICAL WORK DIES

One of the most common uses of the compound die is in connection with the blanking and piercing of parts for electrical apparatus, and a set of tools of this nature are shown by the engraving, Fig. 19.

These dies are for armature disks, and this is an example of the advantages of such tools in producing perfect concentric work which is essential with this class of material. The dies produce a disk with 32 notches, and the close fitting stripper ring for the punch is controlled

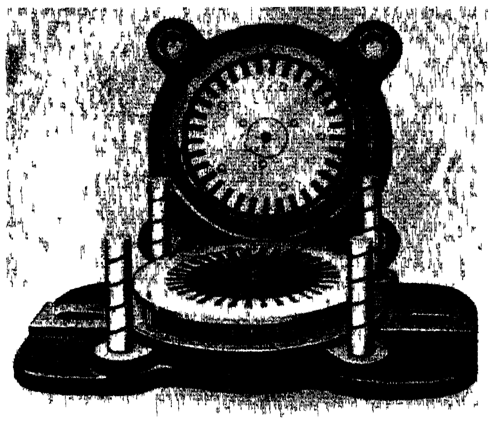


FIG. 19 —Armature disk punch and die.

by the same number of springs, which, with the guide pins, are clearly represented in the lower member of the set.

Dies of this type are employed for making various designs of disks, some with external notches, others with notches inside. Figures 20, 21, and 22 show three forms of such rings or disks as commonly blanked and pierced. Electrical work, like typewriter manufacture, adding machine

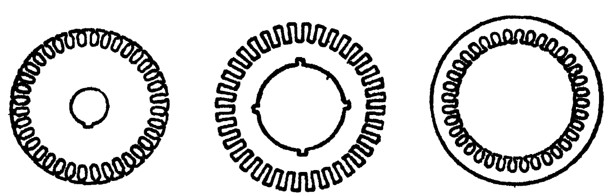


FIG. 20. FIG. 21. FIG. 22.

FIGS. 20–22.—Methods of notching disks for electrical machinery.

and calculating machine work, and so on, requires extensive application of many interesting forms of dies, and certain examples of compound as well as plain dies for these lines of manufacture will be referred to on other pages.

A STATOR PUNCHING DIE

It may be of interest here to show a compound die for a stator punching which is a typical form used by one of the largest manufacturers of electrical equipment. The sketch, Fig. 23, gives an outside and part interior view of such a die with the parts designated by name.

The tool steel die ring is secured to the upper half of the tools and blanks out the work. The lower half serves as the blanking die. It has a stripper plate resting on springs, and this removes the material outside the punching, that is, the corners and margin. The punches for the slots are set into the upper die plate, and there is also a guide plate that serves to hold the punches in position instead of leaving them supported at the ends only. Behind the punch shoe is a member known as a knocker plate which is set into a recess with sufficient clearance to allow of sliding along the axis up and down. This plate is connected with the upper stripper plate or knock-out by screws and knock-out pins. In operation, after the stator punching has been made and the upper die rises, the outer scrap, of course, is lifted by the stripper on the lower punch,

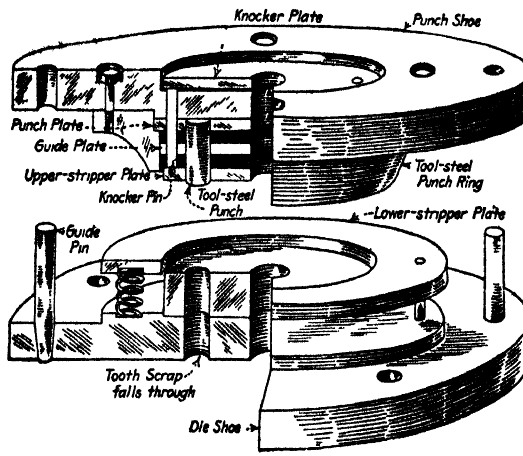


FIG. 23 —Compound dies for stator punchings.

the tooth scrap falling through the lower openings, and the punching being carried up by the upper die until, when the latter is near the top of its travel, a stationary pin strikes the knock-out plate and releases the punching.

It is customary with these tools to harden the die in all cases but to leave the punch soft for dies on such punchings as just shown, to facilitate upkeep and repair.

Limits in Variation

The accuracy with which such dies are made and set up in the press has much to do with the amount of burr found on the work, and it is desirable that definite standards as to the amount of variation permissible should be fixed upon, and the tools then held accordingly. The limits established by the firm referred to and to which punches and dies are held are as follows for stator and rotor punchings: Small round hole dies are to

be kept within plus and minus 0.002 in.; larger round hole dies within plus and minus 0.003 in. Allowance for outside diameter of ordinary punchings made with round hole dies from 6- to 12-in. diameter is −0.004 to +0.006 in.; for 12-in. diameter and up −0.005 to +0.006 in. For

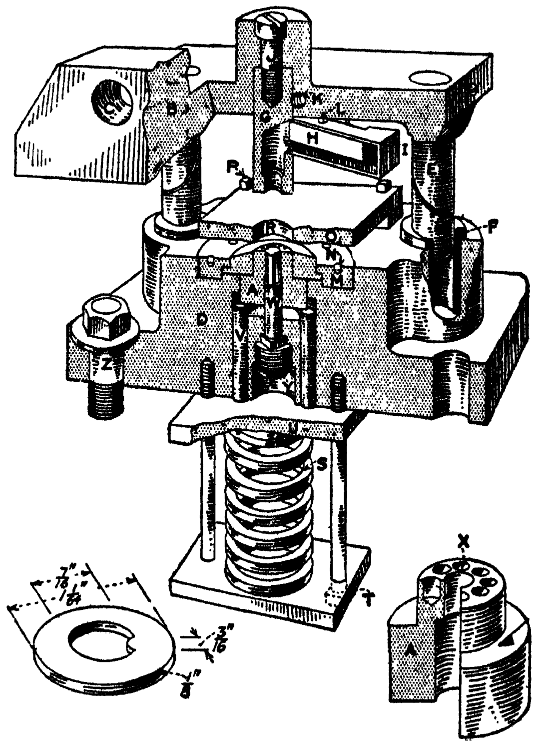


FIG. 24.—Lock washer tools.

rotor and stator punchings made with compound dies the following limits are allowed: From

1 to 15 in.,	+0.002 in.	to	−0.004 in.
15 to 20 "	+0.002 "	"	−0.005 "
20 to 25 "	+0.003 "	"	−0.005 "
25 to 35 "	+0.004 "	"	−0.006 "

The allowance on the bore for rotor punchings, shaft fits, is between +0.001 and −0.003 inch for all diameters of bore. For pole punchings on direct-current machines the variation in height, that is, the difference between inside and outside radius on the individual punching, is allowed to be +0.003 to −0.002 in. for 1 to 4 in. high and +0.005 to −0.002 in. for 4 in. and above.

A Special Form of Knock-out Bushing

Another example of compound die design is a set of tools for making a lock washer from $\frac{1}{8}$-in. steel scrap. One of the features of the die is the knock-out bushing *A*, Fig. 24. This bushing is shown to larger scale in the detail at the lower corner of the engraving. The bushing is so made that it is impossible to plug up the die as long as the operator gives attention to his work.

The knock-out bushing has a series of holes *X* drilled in its face, and these are known as "signal holes," for they will always show whether the last blank has been discharged or not. Should a washer stick in the die and cover the signal holes, the difference between the plain face of the washer and the drilled face of die *A* at once becomes apparent to the operator, who can then remove it before tripping the press.

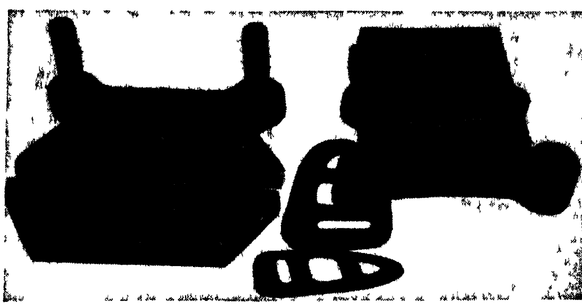


Fig. 25 —Compound dies for a pierced and slotted piece.

The punch shoe *B* is of cast iron and fits the press ram to which it is bolted. The die base *D* is made of cast iron and aligned with the punch by the steel guide pins *E* and bushings *F*. The blanking punch *G* is of hardened tool steel. This punch is counter-bored above the piercing opening for slug clearance and has an opening at *H* through which the slugs are discharged into the chute *I*, which is fastened to the punch shoe by the screw *L* and so arranged that the slugs will fall clear of the die. The punch is held by the screw *J* and kept from turning by a tapered pin at *K*.

The blanking die is a bushing held in place by the threaded bushing *M* which is seated and secured by a spanner wrench fitted to holes *N*. The stripper *O* held by cap screws *P* is open in front to allow the operator greater freedom and a better view while using the die. The opening under the stripper at *R* is necessary in order to let the washer slide off the die when blanked, the press being inclined at an angle of 45 degrees.

The bushing *A* is made of tool steel hardened and ground to size and serves as a knockout for the blanking die. Special care must be taken at

the time of setting up the die to get the proper pressure on the pad *A* by the correct adjustment and tension of the spring *S* and the nuts *T*.

The pressure is transmitted to the knock-out bushing by the plate *U* under the die and the hardened pins *V*. The perforating punch *W* has a square head to prevent it from turning in the die and is securely seated by set screws *Y*. The die is fastened to the bed of the press by the cap screws *Z*.

Two sets of dies for peculiarly shaped and slotted work are illustrated in Figs. 25 and 26. Details are not presented, but the arrangement of punch and die elements is clearly brought out by the photographic views. The metal blanked and spotted out in Fig. 25 is rather heavy gage. The punches for blanking out the interior of this plate are very substantial members, and their proportions are shown due to the fact

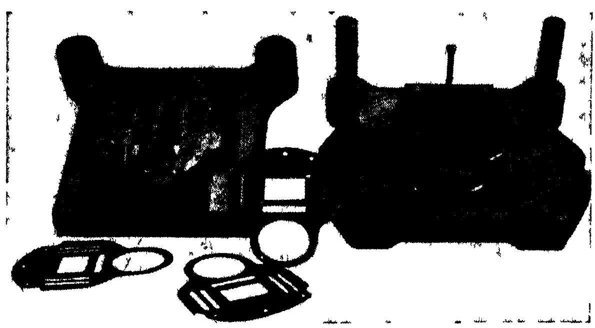


FIG. 26—Compound dies with sheared piercing punches.

that the knock-out for the blanking die on the punch head is withdrawn well away from the cutting face of the die.

The work in Fig. 26 is of lighter sheet stock but is of more intricate form than the other example shown. The close location and narrow proportions of the elongated slots in the sides of the blank have led to the use of sheared or "scalloped" edges for the punches to enable freer operation through the stock with correspondingly reduced likelihood of "dragging" the stock at the edges of the openings as punched out. On the same principle the large circular piercing punch is also ground out at the cutting end with a series of scalloped cutting "lobes," assuring a gradual and accurate application of the cut to the blank.

Compound Stage on Progressive Dies

A die of unusual design in that a compound feature is incorporated on a progressive set of tools is shown in Figs. 27 to 30. These dies were constructed for producing a brass guide plate, Fig. 31, and, as stated, were arranged to include a progressive action of the tools although the first stage is virtually a compound detail. It is in this first stage

that the two semi-circular loops are drawn down and formed by the punches L which shear through the metal and then force the work down into the hollowed seats in dies M, Fig. 30.

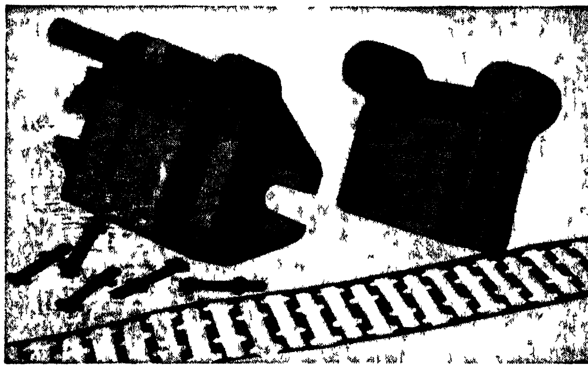


FIG 27.—Progressive die with compound stage.

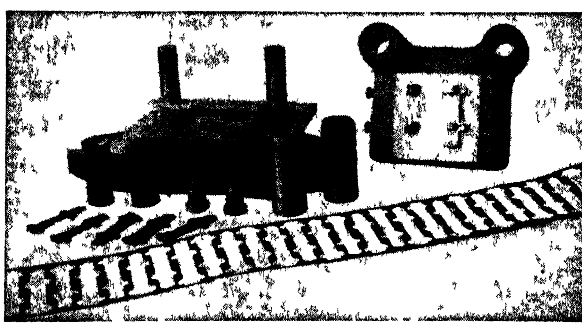


FIG 28 —Die in Fig 27 disassembled

FIG 29 —Showing underside of die in Fig 27.

It has been found by experience that a certain amount of trouble is to be expected in drawing down a loop of this kind in one operation, because there is a tendency for the brass to fracture at the corners of the

semi-circular loop, where it is forced down out of the body of the metal. This is especially the case unless the forming punches which draw the metal down into the loops are given keen cutting edges clear back to the

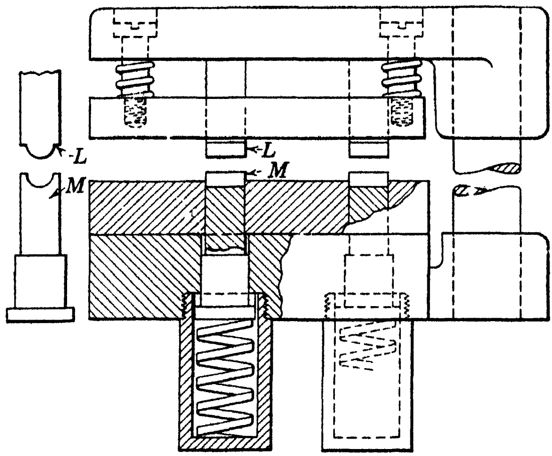


FIG. 30.—Construction of die shown in Fig. 27.

extreme corners so that they can shear the metal cleanly at each side of the loop and allow the latter to be drawn away from the stock.

Further trouble may be encountered in such tools unless the portion of the brass being drawn down into the loop is supported underneath so that in the forming process the work is manipulated and steadied between the punch and die surfaces which remain constantly in contact with the drawn portion during the entire operating stroke of the tools.

The shapes of punch and die faces are shown in Fig. 27 and in the drawing, Fig. 30. The bottom of the die shoe is shown in Fig. 29. The two die members for making the loop are the inserted pair of tools M, Fig. 30. These two parts are machined from round tool steel and have enlarged heads with squared bodies which fit corresponding openings in the die block proper. The upper or working ends of these die members are formed to

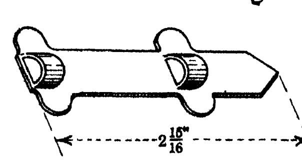


FIG. 31.—Piece made in die, Figs. 27–30.

suit the outside curvature to which the loops on the brass piece are to be drawn. The underside of the die shoe, Fig. 29, is bored out to provide chambers for the die inserts, and these chambers are threaded to receive the hollow housings for the pressure springs, as clearly represented in Fig. 30.

The springs are of $\frac{5}{16}$ square wire coiled with outside diameter of $1\frac{1}{8}$ in. and with a gap between coils of $\frac{1}{16}$ in. The total length of the spring is 3 in.

The operation of the die is a compound action for the drawing or forming of these loops, with progressive arrangement for the blanking which follows the drawing stage. The die plugs inserted in the die block act also as ejectors for the work after the drawing-down stroke. The stripper plate on the punch holder strips the punches. Following the drawing operation, the blanking cut is controlled accurately by the end and side gages and by the pilots on the face of the blanking punch.

The ears of the blanks as they come from this set of dies are pierced in another operation at the same time that a flattening operation is performed to ensure the entire blank being straight and flat along its entire length. The holes, not shown in the sketch, are $\frac{1}{8}$ in. diameter.

The following chapter on the Sub Press and Its Dies deals with a refined type of apparatus which is used extensively on watch and instrument work and for other products requiring extremely accurate dimensions and fine finish of edges and general contour. It is applied mainly to very small or medium-sized work and usually to thin materials. The compound type of die is commonly used in the sub press and for that reason the chapter is arranged to follow directly after the one devoted to compound-die construction.

CHAPTER VII

THE SUB PRESS AND ITS DIES

The sub press which has been referred to briefly in the opening chapter of this volume is used advantageously in many lines of work, particularly where parts to be produced in the power or foot press are quite small, of thin stock, intricate in outline or of very close degree of accuracy. Owing partly to the fact that their range of sizes, as generally made, is somewhat limited, and also to the first cost as compared with the ordinary types of

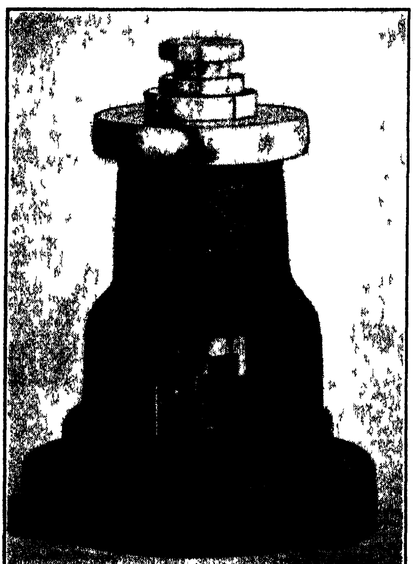


FIG. 32 —Overhung type of sub press

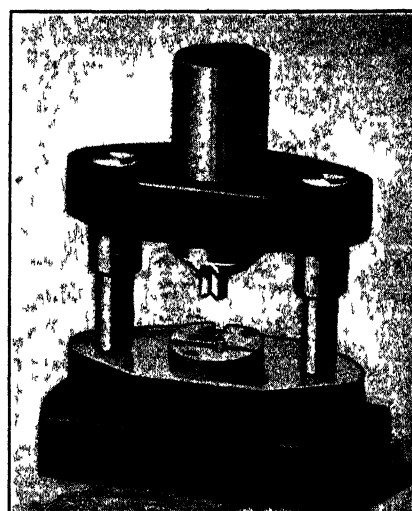


FIG 33 —Pillar sub press

press tools, they are not so generally used as requirements would seem to justify in the average line of close manufacture; although on such work as clock and watch parts, meter parts, and numerous other lines of press work they are employed very extensively.

There are two general types of sub presses, the cylindrical and the pillar, each incorporating the principle, however, of a plunger sliding in a bearing which is attached to the casting that forms the base. The cylindrical type is illustrated by Fig 32, the pillar type by Fig. 33 The latter of course is of the general design that has been so commonly adopted by die makers who have required a more accurate type of press

tool than the plain open punch and die, and who have constructed tools of the general pattern of Fig. 33 for a widely diversified class of operations, not only on small parts but for large blanks as well; for this class of die has made it possible to secure a refined product, and even where no special degree of accuracy is required it has enabled press tools to stand up to their work for a greater period of time, and it has facilitated the operation of setting up the work in the press and simplified the problem of tool upkeep.

With the pillar type referred to, the guide pins may be either on the center line or at the rear of the die base; or the two pillars may be placed at diagonally opposite corners, or again four pillars may be employed, one at each of the four corners of the die. The location and number of pillars employed depend upon the size and shape of the die shoe or base. There is practically no limit to the size of the work that may be handled in such dies except the limiting capacity of the press itself. The various forms of construction differing somewhat in details and materially in dimensions have been illustrated in full in preceding chapters.

As a rule the pillar type of sub press has no provision for compensating for wear; but where an outfit of this character is to be used more or less continuously the pillars may be of hardened and ground steel, and the bearings may be bushed with the same material. The head or punch holder may be provided with a shank to fit directly in the slide of the press, or the shank may be discarded entirely and the punch holder secured to the lower face of the press slide by bolts passing through drilled holes at the ends of the holder and tapped into the press slide. Or again, some form of adaptor may be employed for connecting punch holder and press slide. These details have been covered in connection with various illustrations of dies presented in other chapters.

We have come ordinarily to call such tools "pillar dies" or "pillar type sub presses" and to apply the term "sub press" to the cylindrical or barrel form of die in Fig. 32. This sub press is made in two forms, the overhung pattern of Fig. 32 and the arch form which, as its name indicates, is built with an open arch frame which allows the stock to be passed directly through from side to side. This form of press is generally used for blanking dies, either simple, tandem (or progressive) or compound, as these dies usually work from the strip of metal. The overhung type is preferred for second operations where the blank must be placed individually in the dies, as for such operations as piercing, trimming, shaving, forming, and so on.

While, as already pointed out, cylindrical sub presses as manufactured are necessarily limited in their capacities, it will be of interest to note that they are regularly made with plungers that range in diameter from $1\frac{1}{16}$ in. to 6 in.

From the drawing it will be seen that the sub press has a cylindrical plunger which slides up and down in a babbitted sleeve or bearing held in the housing or barrel by a cap nut at the top. The babbitt sleeve is tapered externally and fits a similarly tapered seat in the barrel, so that it admits of adjustment by means of the nut to retain a fit for the plunger without affecting the original alinement.

The base is finished with a shoulder or hub that is machined to fit the bored opening in the lower end of the barrel. As indicated in the drawing the upper end of the plunger terminates in a button which is machined to fit into a member known as a hook which is secured to the press slide.

Sub presses of this kind, when supplied without the dies, do not have the base and barrel fitted to each other, for it is necessary that the base recess for receiving the punch or die, as the case may be, should be bored at the same setting as the outside of the shoulder or hub is turned to assure their being concentric with each other. It is customary for die makers to bore the opening in the lower portion of the barrel to assure its coming true with the plunger. When these members are once fitted together, they are of course fitted with dowel pins so that they may afterward be taken apart at any time and remounted without disturbing the alinement.

It is obvious from the foregoing that the cylindrical type of sub press has the marked advantage that its recesses for the die, punch and other members, can be bored true with one another more readily than in the case of other designs. It is true, however, that the usual design of press as used for the ordinary open die has insufficient height to admit the cylindrical sub press of standard dimensions, although builders now make lines of presses of suitable range for this form of sub press. Where such machines are not available, the pillar sub press is used.

The Dies of the Sub Press

Typical blanks produced by means of the sub press, and work for which this type of press is especially adapted, are illustrated by Figs. 34. and 35, the first of these representing a group of parts pierced and blanked by tandem or progressive dies, while the second engraving shows a variety of parts as manufactured in compound dies.

There are cases where plain blanks without holes or openings of any kind are preferably made in sub-press dies, because of the positive alinement that enables the closely fitting punches and dies necessary for very thin work to be operated without shearing and with accurate results on the work.

The advantages of progressive dies and the additional advantages of compound tools have been discussed fully in other chapters and need not be entered into here. It may be said, however, that these advantages are quite as marked in the case of the sub-press tools. For if plain blank-

ing or if tandem dies tend to produce blanks that are slightly distorted and which for the most accurate work have to be flattened in another operation, the compound die in the sub press will correct this trouble. And just as the progressive die will facilitate the production of blanks requiring piercing, so will the compound die perform the two operations as one, with entire accuracy between the contour and the position of the openings

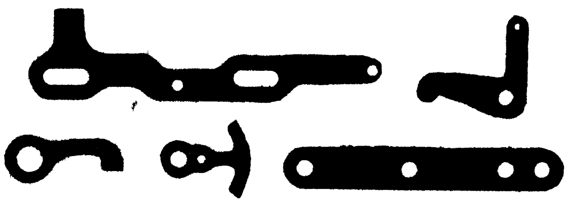


FIG. 34.—Tandem die work in the sub press.

pierced, for there is no shifting of the work between the operations of piercing and blanking. Moreover, as regards compound dies, they will retain their size under numerous sharpenings much longer than other types of dies because of the reduced clearance angle made feasible by the fact that the work does not have to pass clear through, but is instead ejected by a knock-out.

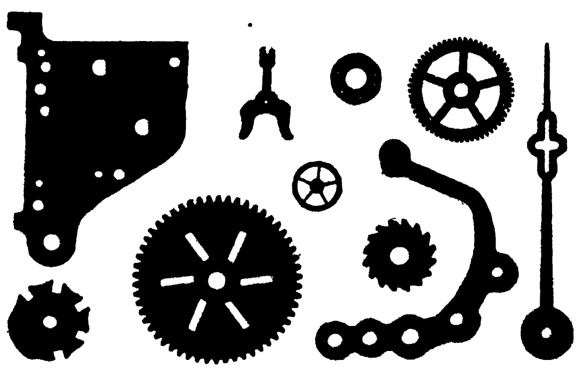


FIG. 35.—Compound die work in the sub press.

In Fig. 36 an arch type of sub press is illustrated with compound dies for blanking and piercing a wheel like Fig. 37. The blanking die is shown at *A*, the blanking punch at *B*. The piercing punch is located at *C* and the piercing die opening is formed at *D* in the center of the blanking punch *B*. The piercing punch is provided with a taper shank which fits a taper hole in the holder *F* and it is further secured by a small screw tapped in from the top.

The punch holder *F* is fastened to the bottom of the plunger *G* by fillister head screws and it has a taper hub fitting deeply into a taper seat in the plunger end. This holder serves as a mount for the blanking die *A* which is located over a taper shoulder as shown and held by the same

screws that pass through the holder F into the plunger. The holder F is drilled to allow the pins H to pass through into contact with the knock-out

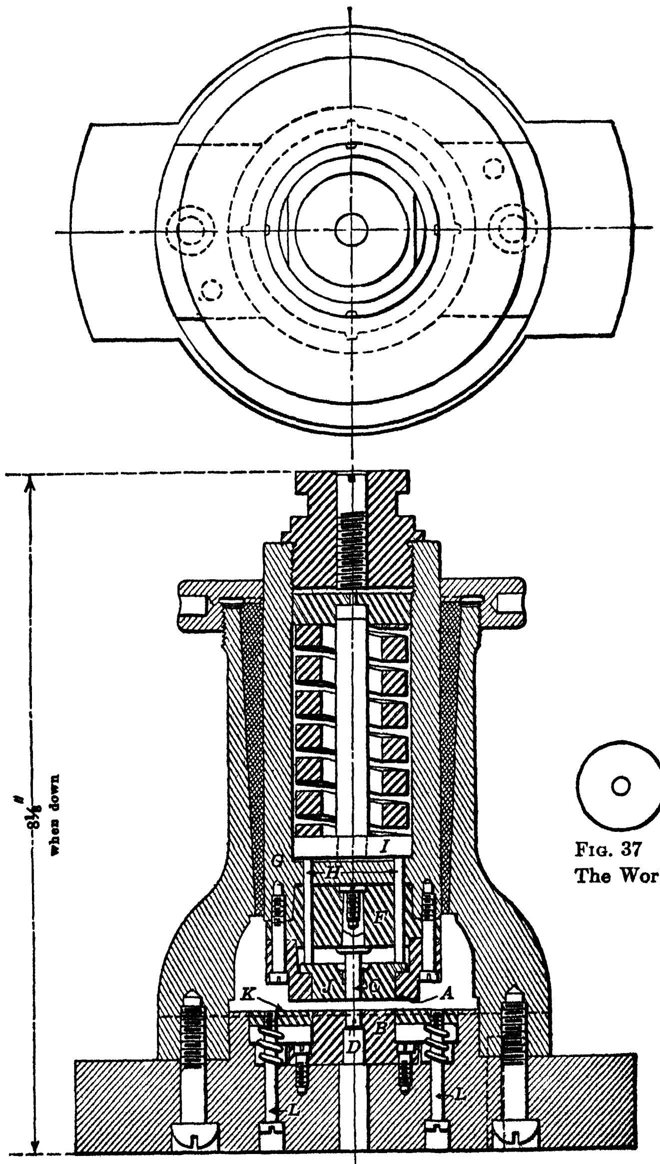


Fig. 37
The Work

Fig. 36

Figs. 36–37.—Arch type of sub press.

I at the bottom of the spring chamber in the plunger. Adjustment of the spring pressure is made by means of the headless screw carried by the

button at the top of the plunger. The pins *H* act against knock-out disk *J* which ejects the blank from die *A* and forces it back into the scrap stock which carries it out of the press.

The stock is stripped from the blanking punch *B* by the spring stripper *K*; this is controlled by coiled springs on fillister head screws *L* which travel in counter-bored holes in the press base when the stripper is depressed by the downward stroke of the blanking die. It will be seen that with this combination of spring stripper and knock-out which act upon opposite faces of the material and work, the blank will be kept free from distortion.

A Clock-wheel Die for the Sub Press

The half tone, Fig 38, and the line drawing, Fig 39, show all details of a compound die for a clock wheel as manufactured in the sub press.

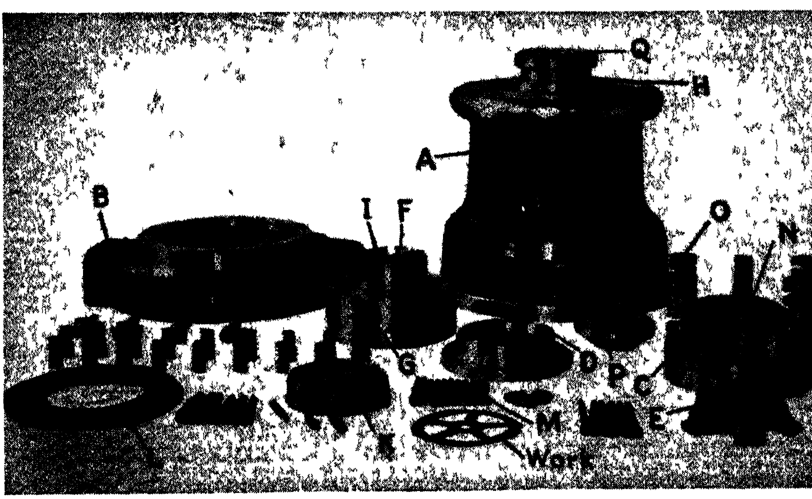


Fig. 38.—Sub press with all details of compound clock-wheel die.

This press is also of the arch type and the clock wheel is blanked and pierced to form the central hole and the five openings between the arms, by feeding the strip of stock through the press between the arched sides of the housing. The wheel produced is 3 in. in diameter.

In referring to the various members of this set of tools the same letters are used on both engravings for purposes of identification. Thus, *A* is the housing which in Fig. 38 is shown removed from the base *B* to allow the punch and die parts to be taken out; *C* is the blanking die for cutting out the wheel, and *D* the blanking punch. The latter fits over the spider shaped piercing die *E* whose five arms define the edges of the triangular openings punched out by piercing punches *F* to form the five arms of the wheel. These piercing punches are built up of five blocks of tool steel

finished externally to a taper form of shank to fit into a tapered seat bored and ground in the holder *G*. The holder is also ground externally to a slight taper to fit a corresponding taper in the lower end of the plunger *H*. Fillister head screws and dowels are used to secure the piercing punches in their holder and the latter is held by similar devices in the plunger. The holder further carries the small piercing punches *III* (three in number) which are located at the center for piercing the three holes in the blank. The upper dies are provided with the spring-actuated knock-out ring *K*, *K′*, and the lower tools with the spring controlled stripper *L*. The knock-out ring *K* is operated by pins *M* extending upward to thrust plate *N*, and the five armed center of this knock-out which is indicated at *K′* is similarly acted upon by other pins abutting against the plate *N* above.

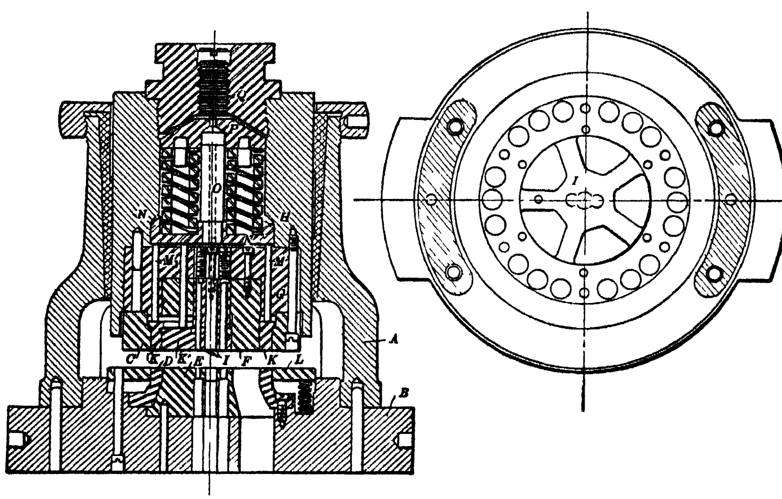


FIG. 39.—Construction of sub press with compound clock-wheel dies

This pressure plate is backed up by four stiff square section coiled springs *O* which are confined in seats between plate *N* and the top plate *P*, the latter being adjusted as required to regulate the spring pressure, by means of the headless screw tapped through the button at *Q*.

The various minor details such as screws, small springs, and dowels are all shown clearly in the two engravings and no special reference to these parts is necessary.

SUB-PRESS TOOLS FOR A CLOCK FRAME

Another interesting sub-press equipment for making a clock frame is illustrated by Fig. 40. This view shows the work in the foreground, also a smaller piece which is attached to the frame and which is made at the same time, by blanking it from the material between the two projecting arms of the frame.

The frame blanked and pierced is shown at *A* and the smaller piece of work at *B*. The blanking die *C* is made to be attached to the lower end of the plunger *D* and the blanking punch *E* is fitted to the base *F*. The piercing punches are carried by the same holder as the blanking die *C*, and the stripper and knock-out for this die and the piercing punches is made as

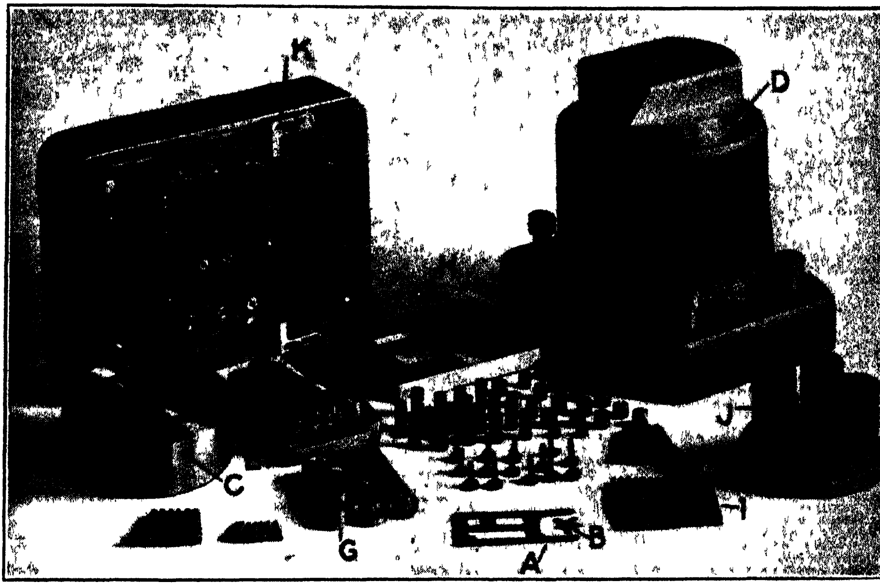


FIG. 40—Sub press with details of dies for clock frame.

shown at *G*. The stripper for the blanking punch *E* is shown at *H* and the springs and screws for both *G* and *H* are seen at the front and side of these two members. In the same group will be noticed, also, the knock-out pins *I* and the pressure springs *J*. The two adjustable stock gages or guides are represented in position at *K*. The manner in which these parts assemble in the plunger and base will be understood from the foregoing and from the sectional views of the other dies which have already been described.

Section III

DIES FOR SHAVING AND TRIMMING

CHAPTER VIII

SHAVING DIES AND SHAVING ALLOWANCES

The shaving die does for the sheet metal blank what the grinding machine does for machine parts requiring accurate sizing and smoothly finished surfaces. It accomplishes this finishing operation, however, not by an abrading process but by removal of a slight amount of material from the edge of the thin blank by means of a shaving cut. In extremely important instances, and especially in such instances if the blank is fairly thick, two or more shaving cuts may be required.

The shaving die is as applicable to the finishing of a pierced opening as to correcting the outside of the blank; or, again, it may find its best field in work in the finishing of a portion of a piece where a contact point or lug may require to be exactly located in respect to a hole or a surface by which the work is carried possibly through several subsequent operations.

While the cost of running blanks through a second operation of this character—where it is necessary to nest the piece—is considerably higher than that of producing the blank in the first place, there is in the use of the shaving process a decided saving in maintenance of blanking tools in that these do not require holding to the degree of precision essential for some parts where no shaving tools are used for second operations. While the allowance for shaving normally provided for is quite small, it is still sufficient to permit of reasonable wear in the blanking dies themselves, thus leading to a corresponding degree of economy in upkeep of these first operation tools.

The shaving die is a desirable means of finishing such stamped parts as small gear wheels and other toothed elements, ratchet wheels, cam surfaces and cam levers, small rocker arms, and a host of other medium gage pieces of the general type entering into construction of business machines, instruments, coin controlled mechanisms, and similar equipment where close accuracy is essential to continuous and perfect action of all elements entering into the device.

Uses on Heavy Stock

As heavier gages of stock come to be considered, the shaving die becomes almost a necessity if best results as to size and finish are to be expected. For the heavy stock imposes severe duty upon the blanking dies with corresponding degree of wear, and the thick edge of the blanked

metal is apt to show a quality of roughness which is oftentimes unnoticed with lighter gage material. The sharpness of the corner is lost, and the edge may assume an appearance of having been swaged in the blanking process. Also the cut edge may be rough and torn, a condition likely to be aggravated appreciably with certain grades of stock of heavy gage.

Some instances, where shaving operations are of prime importance, are as follows: Small toothed wheels where accurate surfaces are required for the gear tooth curves and smooth edges are essential. Small levers and rocker arms, etc., where certain contact points or bearing surfaces must be exactly finished in relation to other portions of the blank. Toothed segments and sectors where the conditions are similar to those pertaining to gear wheels as noted above. Certain pierced members requiring exact relationship between, say, a cam slot or a central opening in respect to the external surface. Here an internal shaving process is required for the pierced openings as well as for the blanked exterior.

Occasionally a blanked piece has to be shaved only at, say, one end, as for a rounded bearing point or a short contacting projection. In such cases the shaving dies may be made to operate only on the limited section where special qualities of accuracy and finish are desired. In such instances the shaving tools approach in function certain classes of trimming dies where the action of the tools is to cut away a small amount of material at some point on the edge of the work to change the form as blanked to the modified contour desired, as, for example, in trimming a rounded lug or shoulder to a "V" or other form. Usually, however, the trimming die has a considerable amount of material to remove and is thus differentiated from the shaving die which, as its name implies, takes only a very thin cut, a few thousandths at the most, on a side. In fact the amount left for shaving is sometimes divided between two cuts in first and second shaving dies, and the latter is then required to remove even a smaller amount of material than is generally left for the single shaving operation.

Shaving Tools for a Gear Wheel

As an illustration of an accurate set of shaving dies, Fig. 1 is presented herewith showing the application of the double shaving principle, two sets of shaving dies being included in the equipment with the work of shaving divided between them; he amount left for the second shave is one-half that taken off by the first shaving dies. While there are, as stated, two shaving operations on the blank, the shaving tools are essentially the same in construction as a single shaving set would be, the sole difference being in respect to the diameter of the dies which in the present instance allow for the taking of the two cuts which, with the single shaving die generally used, would be confined to one cut only. This set of dies

has been selected as the first illustration in the present chapter for the reason that the work produced forms a characteristic example of the class of parts to which the application of shaving dies is especially advantageous.

The blanking tools are seen to the left in the half-tone, and no special description is required, as they are of practically the same design as the set of wheel dies illustrated by Fig. 46 in Chapter II. The blank produced is a ten-tooth wheel punched out of 0.050-in. half-hard steel stock. The outside diameter of the gear wheel is 0.751 in., the depth of tooth 0.139 in.

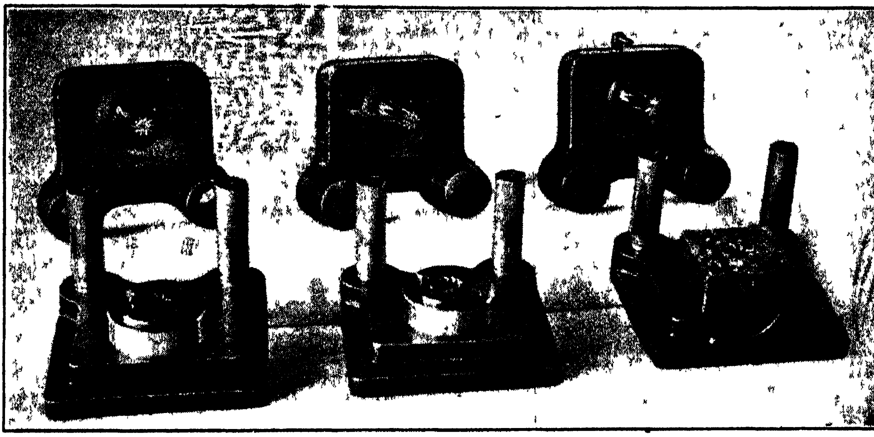


FIG. 1.—A set of dies for blanking and shaving a small-toothed wheel

THE SHAVING DIES

The two sets of shaving dies are alike except for the slight difference in diameter of punch, die opening, and nest. The sketch, Fig. 2, gives the details of construction with a few important dimensions. The die proper is of tool steel finished to 3-in. diameter, hardened, and finally secured by screws and dowels to the shoe or base. To this die is attached the nest, or "set edge," as it is sometimes called, for locating the work over the opening in the die.

As the shaving die is used expressly for securing accuracy in the work, as well as smoothness of contour, it is desirable to make the interior of the die straight instead of with the half-degree clearance on a side commonly found in blanking dies. At the same time the difficulties commonly encountered in working out such a die opening with perfectly straight sides for the full depth of 1 in. or more generally results in the adoption of a compromise on this point, and the practice in various shops is generally to work the die out straight for a depth of $\frac{3}{16}$ to $\frac{5}{16}$ in. dependent upon the thickness and nature of the material and then clear the die below the straight portion.

It is often found at the die maker's bench that the attempt to produce a perfectly parallel die opening from top to bottom results in a bell-mouthed hole instead of a straight one; and while, in various instances where special requirements demand it, straight dies can be and are

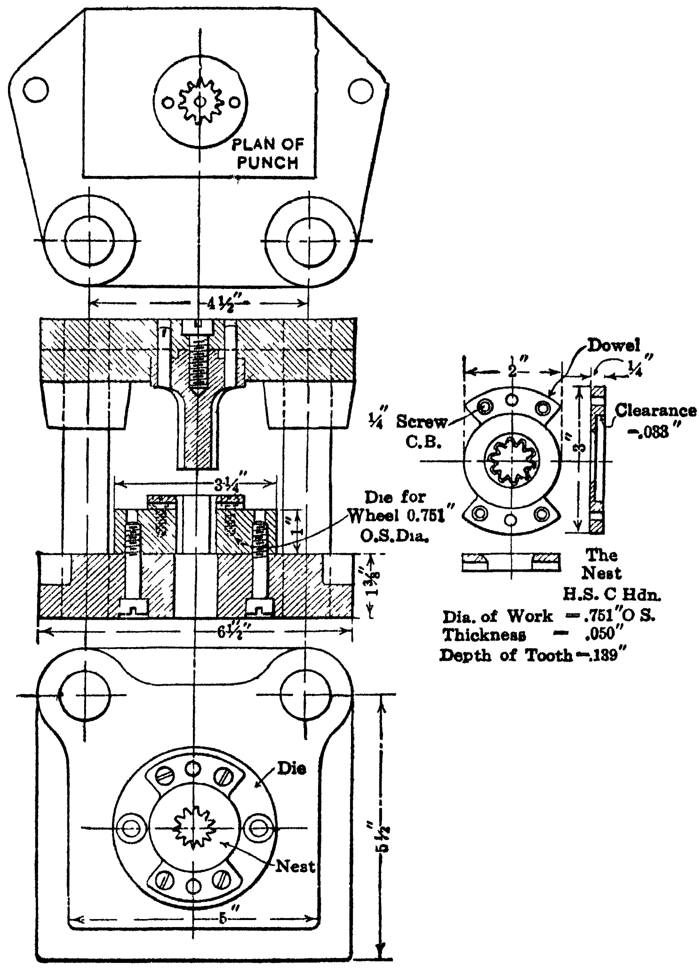


FIG. 2.—Shaving dies for small gear.

regularly produced, it is usually considered wiser and more economical practice to limit the straight portion of the opening to the amount specified and clear the remainder of the depth by giving each side the customary half-degree taper. This course naturally shortens the life of the die as compared with the probable working period through which it might be used if made with no side clearance at all; but, with the usual

materials finished by shaving, the wear on the dies is comparatively slight, and even with their limited working depth (which is balanced in a large measure by the fact that only a small amount of the surface is removed by each regrinding) they should answer for a large amount of work before requiring replacement.

With shaving dies for german silver, however, it is customary in some shops to make the die straight or parallel all the way through. The shaving of such material imposes severe service upon the cutting edges of the tools; and if they were made in accordance with the practice noted above, their life would be very materially shortened.

Allowances for Shaving

It is of importance at this point to give a little consideration to the subject of allowances for shaving of blanks. As for any given material, or grade of stock, the condition of the contour of the blank will vary with the thickness of the metal; the amount left for shaving should likewise vary and with a fair degree of uniformity from the thinner gages to the thick material. Similarly the allowance for any given thickness should vary for soft, half-hard, and hard material. In order to cover these allowances for steel blanks of the three grades noted, Table 1 has been developed and has been given thorough tests in connection with numerous shaving dies operating on different classes of work.

This table covers thicknesses of metal from $\frac{3}{64}$ to $\frac{1}{8}$ in. inclusive and also includes allowances for german silver and brass. For these two materials, it will be noted, the shaving allowances are double those for steel of the same thickness. Table 2 is arranged to give allowances where two shaving cuts are taken. From the quantities under the heading "Allowance for second shave" it will be seen that the amount left for the second shaving operation is one-half that for the first. Thus in the case of a soft steel blank $\frac{1}{16}$ in. thick requiring two shaving cuts, 0.003 in. would be allowed on a side for the first shaving die to remove and 0.0015 in. for the second shaving operation, or a total of 0.0045 in. on a side or 0.009 in. over all, the blanking dies being made 0.009 in. larger than the finished size of the piece.

With reference to the dies in Figs. 1 and 2, for the gear wheel of 0.050 in half-hard steel, the first shaving die would be made to remove 0.003 in. on a side, and the second shaving die to finish the piece by removing 0.0015 in. from each side. The blanking tools then must be made larger in diameter than the finish gear dimensions by twice the sum of these two allowances or 0.009 in.

Nests for the Work

The form of nest or locating device on shaving dies varies with the form and size of the work, but there are certain conditions to be observed in

common in practically all cases. Thus as much clearance as feasible should be provided at the underside of the nest to allow for the ready blowing out of all chips produced in the shaving process; the top face of the nest should be beveled out or chamfered around the contour of the opening to provide an easy locating medium for the work; the nest opening itself should be just enough larger than the blanked piece to admit the latter readily but without permitting it side play. It should ordinarily be the size of the blanking punch, and it may therefore be finished by using the blanking punch for a final broaching tool in working the nest opening to diameter. Under this condition ample clearance will be formed in the nest opening for the shaving punch, as the latter is a close fit to the shaving die and is therefore at least several thousandths under the diameter of the nest itself.

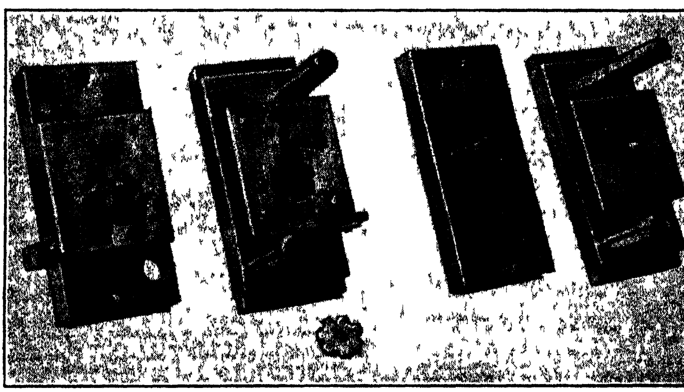


FIG. 3.—Progressive piercing and blanking tools and a pair of shaving dies.

As to the chip clearance at the underside of the nest this may well be equal to about two-thirds the thickness of the blanks. A good standard for the nest thickness for the general run of shaving dies is $\frac{1}{4}$ in. as indicated in the sketch in Fig. 2 and with the above ratio of clearance space underside the gap cut out for a blank 0.050 in. thick will be 0.033 in. as given on the detail.

The shape of the outside of the nest is best developed toward an approximation of the contour of the blank to facilitate the maintenance of a perfectly clean surface under the nest itself and across the face of the die. This applies more particularly where the shaving die is of the pattern illustrated in Fig. 2 with opening clear down to allow the work as shaved to pass down through the die and shoe.

OTHER DESIGNS OF SHAVING TOOLS

While the foregoing method of shaving blanks by pressing them down through the die one after another is presumably the most commonly employed, there are numerous instances where such dies are designed for

ejecting the shaved blank from the top of the die. Also, the tools are occasionally arranged to operate in inverted order with the die at the top and the punch below. Then, again, while the conventional nest is one that locates the blank on the die by means of its external edge or contour, examples are frequently found where an opening at the center or in some other portion of the blank allows an internal nest or pilot to be employed to advantage, particularly where it is desired to shave the edge in accurate relationship to a pierced hole of this character. An illustration of this arrangement is presented in Fig. 3.

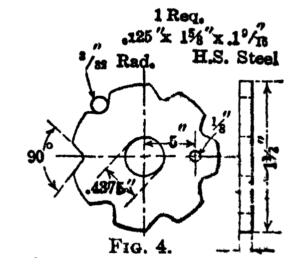


Fig. 4.
A Blank Requiring Chains

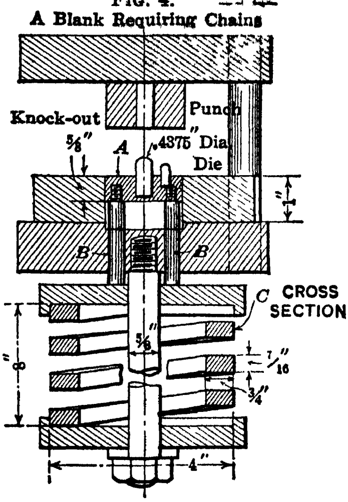


Fig. 5.

Figs. 4-5.—Sectional view of shaving dies.

A Piloted Shaving Die

Referring to this view, a set of progressive piercing and blanking tools will be seen to the left, while at the right-hand side is shown the shaving punch and die. The blank produced with the progressive die is sketched in Fig. 4 and will be seen to be a steel disk $1\frac{1}{2}$ in. in diameter by $\frac{1}{8}$ in. thick, with six 90-degree notches in the edge and a central hole measuring 0.4937 in. in diameter. One-half inch from the center there is a $\frac{1}{8}$-in. hole which is pierced at the same time as the central opening.

For the shaving operation that follows, a die is used which is fitted with a spring knock-out or ejector in the top of which a $\frac{7}{16}$-in. locating pilot or nest pin is secured while a $\frac{1}{8}$-in. pin is placed at a distance of $\frac{1}{2}$ in. to correspond with the smaller of the pierced holes in the blank. The two pilots thus serve as a means for locating the blanks for the shaving process.

The construction of the die is brought out by the sectional view, Fig. 5, which is included here to represent the method of removing the shaved piece from the die opening. The knock-out A is $\frac{5}{8}$ in. thick and has a possible movement down into the die opening of $\frac{3}{8}$ in. It is provided with a series of pins B which are acted upon by the heavy pressure spring C to lift the knock-out and eject the shaved blank. The spring is confined between two disks, and the central stud tapped into the bottom of the die shoe secures the attachment in place. It may be readily transferred to any other die requiring similar knock-out apparatus.

As stated, the knock-out disk A carries the central locating pilot for receiving the work and also has a second pin for entering the $\frac{1}{8}$-in. hole in the blank. The punch is provided with a central hole for the top of the pilot pin. The disk finished with these tools is part of the mechanism of a

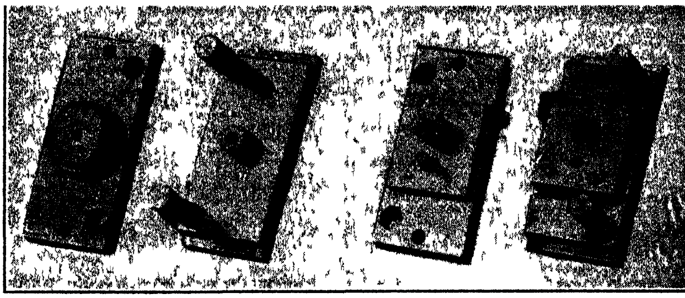


FIG 6 —Dies for making a gear wheel

coin register. Another piece for the same machine is shaved with the tools illustrated in Fig. 6

INVERTED SHAVING DIES

These tools are of the inverted type, and the blank is located by placing it over a nicely fitted pilot which, in this construction, is inserted in the punch, the latter forming the lower member of the set of tools. The shaving tools are at the left in Fig. 6 while at the right in the same view are a set of progressive blanking and piercing dies for piercing the central hole and producing the blank ready for shaving. The piece itself is shown with principal dimensions in Fig. 7.

It is a gear wheel of steel, $\frac{1}{8}$ in. thick, 1 875 in. outside diameter, with 28 teeth which must be accurately finished on their contours and concentric with the 0.406-in. hole at the center. The shaving die, which is adapted to be attached to the ram of the press instead of to the bolster and thus used bottom side up, as shown by Fig. 8, is made up in the same manner as if constituting the usual lower member of the set. It is finished internally to the size for shaving for a depth of $\frac{3}{4}$ in. and is cleared beyond that point.

In use, the work is located on the punch face by means of the pilot, and the die upon descending with the press slide accomplishes the shaving operation and rises with the blank inside. The clamp on the front of the slide for holding punch shanks is removed from the slide to leave a liberal opening over the top of the die shoe, and as the shaved blanks pass one by one up through the die they are swept out of the slide opening by the operator. With both of the shaving dies in Figs. 3 and 6, the seat for the blank is readily kept free of chips and dirt, and there is no trouble in nesting the work properly.

Comparative Advantages

The two types of dies, as best seen in the sectional views, Figs. 5 and 8, have their advantages for certain classes of blanks requiring shaving, not the least of which is the feature just referred to—the convenience with which the die face is kept clean. The dies in Fig. 5 are used in this par-

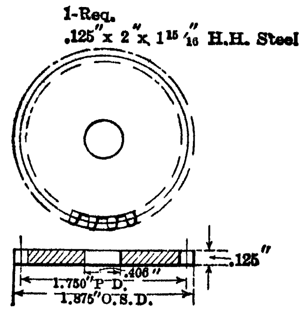


Fig 7.

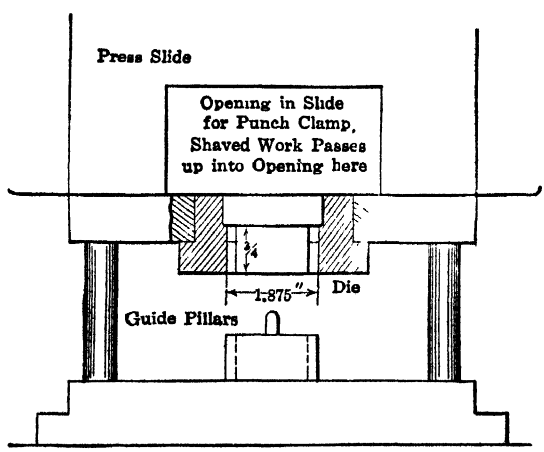


Fig 8

Figs. 7–8.—Method of resting the work on a pilot with inverted die.

ticular instance for a thick blank; with thinner work the advantages of the knock-out are more apparent, for the disk *A* then serves as a holder to confine the blank between its face and the end of the punch, and by supporting the work fully during the shaving operation it assures its being ejected from the die in a perfectly flat condition.

The knock-out also prevents possibility of thin shave blanks stacking up or wedging tightly in the die with likelihood of injury to themselves and the tools. This possible source of trouble with such work is guarded against in a measure in the usual type of die with opening clear through,

by confining the sizing part of the die to a limited depth of $\frac{3}{16}$ to $\frac{5}{16}$ in., as already pointed out in this chapter. The clearance below then allows the work to pass out freely at the bottom. This occasional tendency upon the part of shaved blanks to stack up in the die is quite similar to

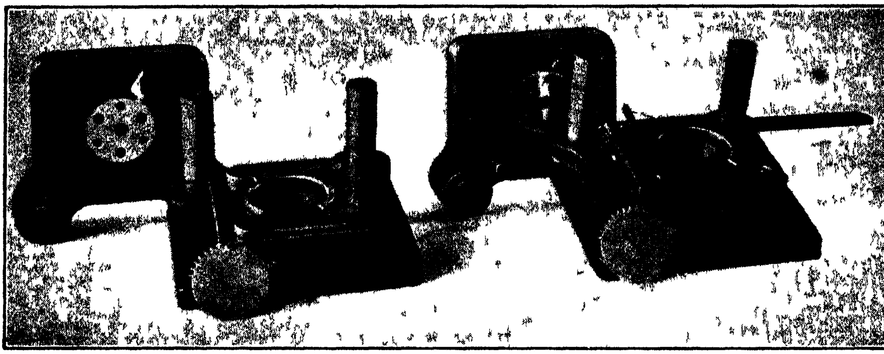


FIG 9 — Blanking die and a shaving die for outside of work

the action of slugs from a piercing punch which with an improperly cleared die will tend to swage against each other and the sides of the die opening and cause trouble of a more or less serious nature.

With the inverted type of die in Fig 8, the chips or shavings removed from the edge of the blank at each down-stroke of the press

FIG. 10 —Dies for piercing and shaving center hole and notched teeth.

are carried down over the edge of the punch from which they are readily cleared.

TOOLS FOR A TOOTHED CAM MEMBER

The shaving of an unusual form of blank, requiring the accurate finishing of two or three different surfaces, external and internal, involves at

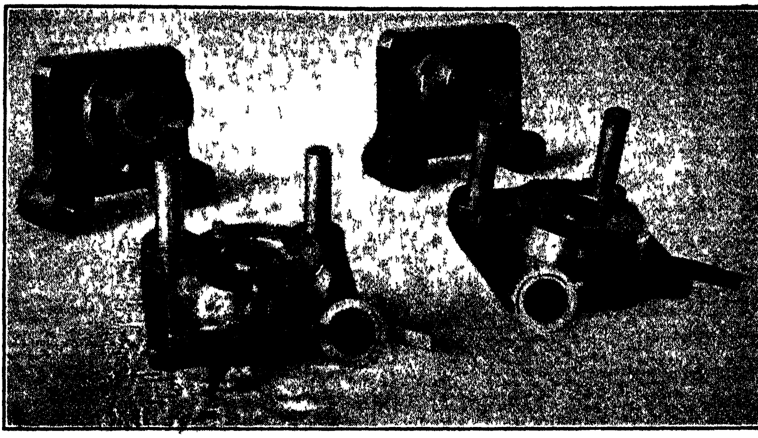


FIG 11 —Dies for piercing and shaving a cam slot.

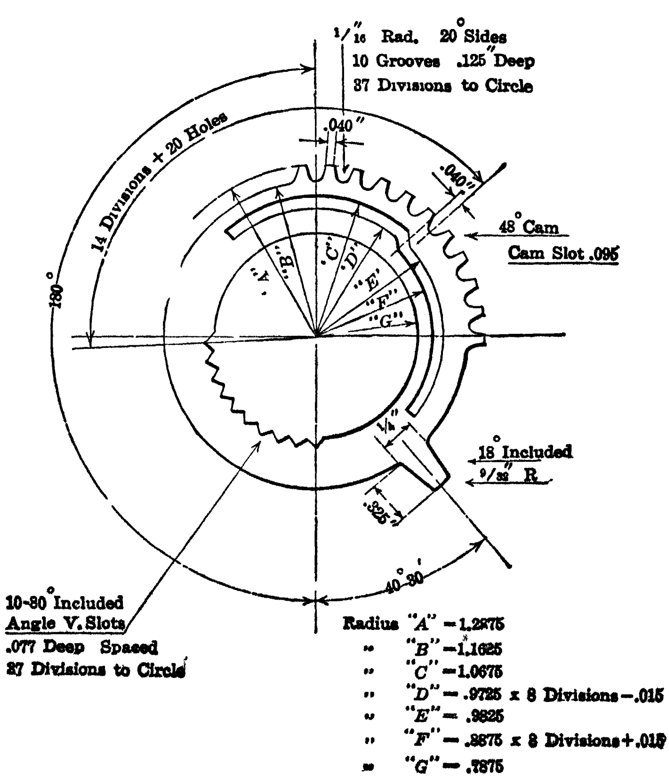


FIG 12 —The work produced in the tools in Figs. 9–11.

times the application of several distinctive shaving operations in as many separate dies. It is a problem of this character that is taken care of by means of the tools in the views that immediately precede.

The three photographs, Figs. 9, 10, and 11, represent three sets of tools, each made up of two pairs of dies for blanking, piercing, and shaving the piece shown by Fig. 12 which is one of nine similar members used in a certain machine and constituting as a group what is known as a setting drum.

The nine drum disks are all made to the dimensions given for outer diameter, diameter of center hole, size of teeth inside and out, and length and width of the cam slot. The angular relation, however, of the latter slot in respect to the groups of teeth and the projecting lug at one side varies throughout the set of disks; for the cam slot in each is utilized to operate an individual controlling key which is adjusted radially through the necessary distance by the cam slot which acts upon the head of the key. The position of the rise in the cam slot is therefore of importance, and its variation around the disk as a whole throughout the series of nine disks has led to the design of a group of press tools of unusual interest.

General Principles

The disks are of german silver 0.050 in. thick, and they are blanked from stock $2\frac{5}{8}$ in. wide. The blanks for the series are all alike externally, and so one set of blanking tools answers for all of them.

This blanking operation is followed by an external shaving cut which finishes the outside contour completely. Then the shaved blanks are passed through a set of piercing dies which form the hole at the center and the internal teeth. This operation is followed by the shaving of the center opening and the inner teeth, and then the cam slot is pierced, and in another set of dies the slot is shaved.

Up to the point where the slot is to be pierced the disks are all uniform, involving no complications in the construction of the dies. But for the operations in connection with the slots, special forms of nesting devices are required in order to give each slot the exact individual position necessary for that particular number of disk. That is, there are nine distinct positions for the slots in the different disks, and this variation is secured by an adjustable nest which enables one set of dies to pierce all slots correctly and another set to shave them accurately, thus avoiding the necessity of nine separate sets of dies each for piercing and shaving.

Blanking and Center Piercing

The blanking dies for the disk are shown to the right in Fig. 9 and require no special description, as they are similar in general design to

various other tools already shown in detail in other chapters in this book. It will be noticed that the trigger form of stop is used for the stock, and the dies are so laid out as to bring the projecting lug of the blank at an angle of about 30 degrees with the cross center line to permit of the use of a minimum width of stock. The punch resembles one for an interrupted-tooth wheel, and the portion for blanking out the lug is dovetailed into the edge of the body of the punch. Three fillister head screws and three dowels locate and secure the punch to its holder or head, which, as will be seen, forms with the die base a set of subpressed or pillar dies.

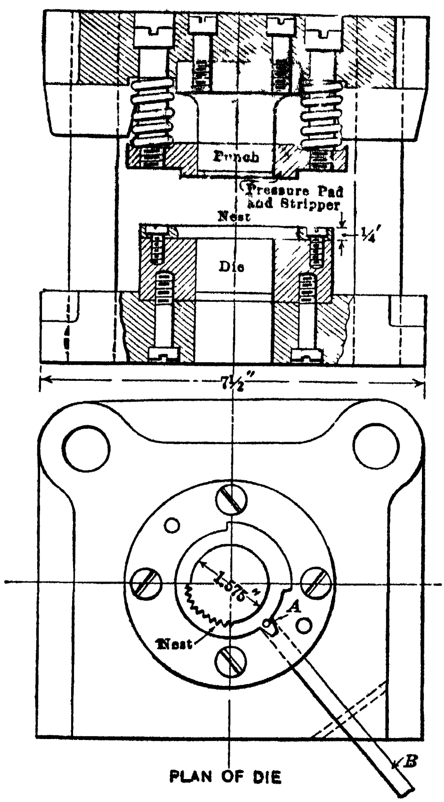


FIG. 13.—Arrangement of nest on shaving die

The shaving tools at the left in Fig. 9 are provided with a locating nest shaped along similar lines to the one described in connection with Fig. 2, although the proportions are somewhat different to correspond with the larger size of the blank to be shaved. The stock being 0.050 in. thick, the amount removed on a side by the shaving die is 0.005 in. as indicated by the value for that thickness under the column for german silver in Table 1 (p. 197).

The dies at the right in Fig. 10 pierce the center opening and form the internal teeth, and the tools at the left in the same view accomplish the internal shaving operation required for finishing the inside contour. The nesting of the blank is accomplished in the same manner for both sets of dies, and the sketch, Fig. 13, will give a good idea of the general arrangement of the various parts of the tools. While the latter view is more specifically related to the shaving dies, it represents as well the essential features of the dies for the piercing operation.

The form of the nest is a close outline of the blank, and its depth of ¼ in. is relieved around the opening by a liberal chamfer which removes the corner for one-half the thickness of the nest. The punch is provided with a combined pressure plate and stripper which serves to hold the work flat during the operation of the punch and which strips the punch

upon the up-stroke of the slide. Both dies for the piercing and shaving cuts are provided with ejectors in the form of vertical pins *A* which are

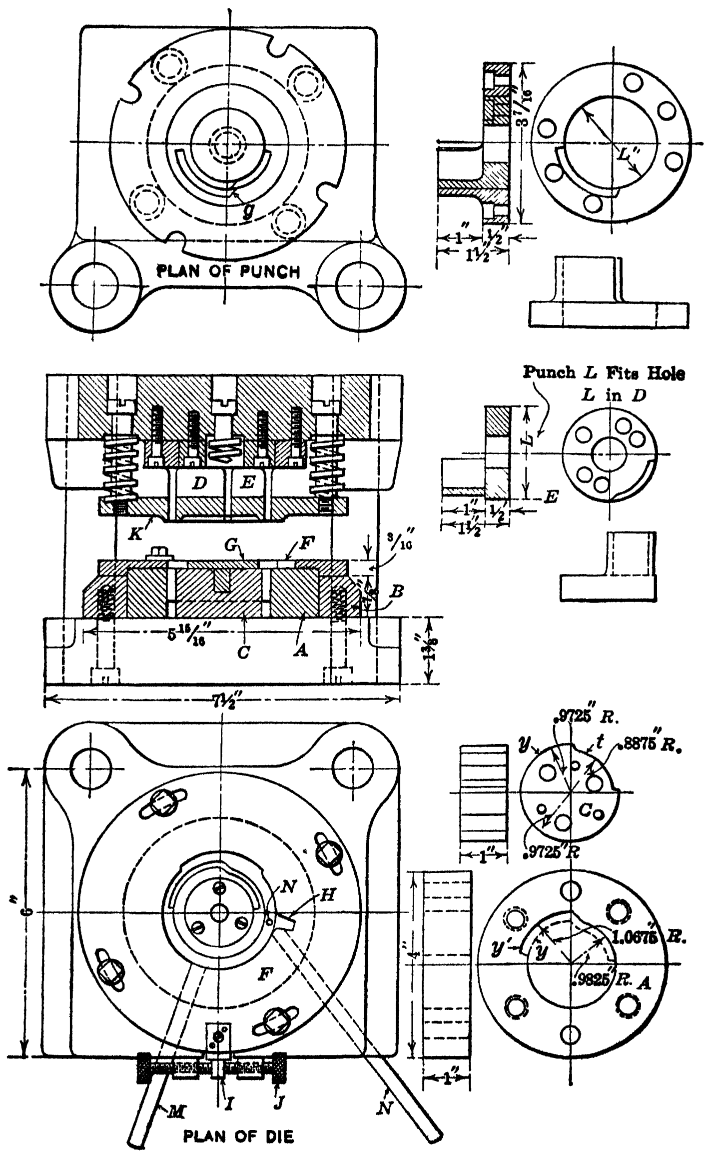


FIG. 14.—Details of slot-shaving die.

located under the blank and are operated by downward pressure upon the end of the handle *B*.

PIERCING AND SHAVING THE CAM SLOT

Proceeding now to Fig 11, we find here some most interesting features in die construction These tools pierce and shave the cam-shaped

Fig 15 —Slot-shaving dies taken apart

opening, and as they are alike in the main, the description may well be confined to the shaving die details which are clearly brought out by the drawing, Fig 14, and by the photographic groups, Figs. 15 and

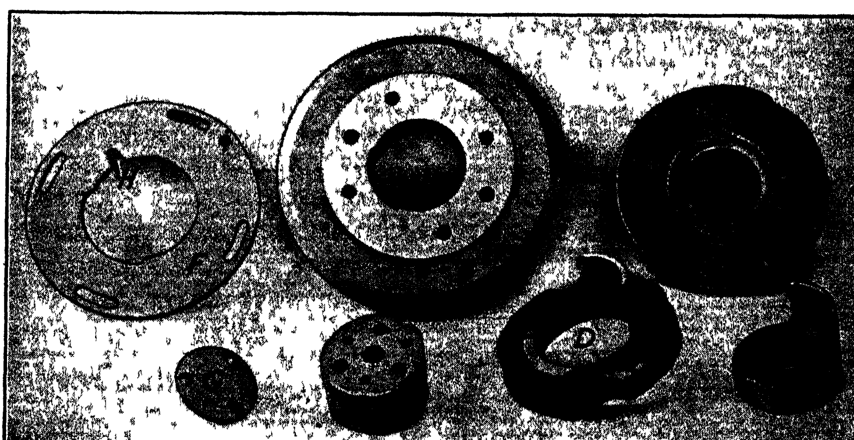


Fig. 16 —Details of slot-shaving dies

16, which show the principal die parts as they appear when the tools are taken apart.

These dies, as pointed out, cover in the one set the positioning of the nine differently located slots in the disks. They are of sectional construction with punch and die proper each made up of two parts ground to correct relationship to one another.

With reference now to Figs. 14, 15, and 16, where the same reference letters are used for the three engravings, A is the main portion of the die which is pressed into a steel ring B by which it is secured to the die shoe. This die A is finished out to a radius of 0.9825 in. except for the portion for the high part of the cam slot which is cut out to a radius of 1.0675 in. The greater part of the bore may therefore be finished by grinding to a diameter equal to twice radius 0 9825 or 1 9650 in.

The smaller section of the die proper shown at C is ground for the greater part of its circumference to a diameter corresponding to the interior of the main die A and made to fit closely therein. A part of the circumference of C is, however, reduced to a radius of 0.8875 in. for the low portion of the cam slot, this being shown at x; and at y another portion of the outside surface is reduced to a radius of 0.9725 in. to give the proper width of gap between that portion and the corresponding edge y' of the main die A. These figures may be checked up with the radii given on the drawing of the work in Fig. 12 and will give a clear idea of the manner in which the proper width of slot is provided for between the opposing faces of the two die members described. The position of the holes for the screws and dowel pins for securing the die parts to the base or shoe will be seen in the drawing, Fig. 14, and also in the group photographs.

The Punch Parts

Similarly, the punch proper is constructed with two parts, outer and inner, which facilitate the making of these members. The larger punch part D is made with a piercing projection of long enough arc to cover the high portion of the cam slot, while the inner member E is constructed to pierce the low portion of the slot.

The base of the punch E is finished to fit closely in the opening through the bottom of punch D, and the two members when put together over-lap at the cutting ends as at z to give a smooth, continuous cut through the slot at the point where high and low cam slots meet, and the edges of both punch parts are beveled at the necessary angle at z to give the correct slope to the cam slot rise. The cutting portions of both punch members are ground after hardening to give the required inside and outside radii.

The Adjustable Nest

The work to be shaved is placed in the adjustable nest F, where it fits with its shaved center located over the thin pilot disk G and with its projecting lug in the notch in the nest at H. The latter gives all the pieces to be shaved a definite position in the nest, and it remains only to adjust the nest upon the die to secure any desired location around the circle for the cam slots. This adjustment is secured as follows: The nest is seated by a recess in its underside which fits over the top of the die ring A. It is

adapted to be clamped in position by the four screws passed through the curved slots near the edge. At the front is secured a short arm *I* which is engaged by the opposing thumb screws *J* for adjustment either to right or to left. Thus while the punch and die remain in fixed position, the nest and work may be adjusted to a master for the locating of the slot according to the requirements for that particular job. After one lot has been run through the dies, the nest is reset for the next number in the series of cam disks, and so on with the entire lot.

The punch holder is fitted with a spring-actuated pressure pad and stripper *K* which is backed by five springs, one of which is located at the center where it passes up through the sectional punch into contact with the back of the stripper. There is a knock-out in the die slot actuated

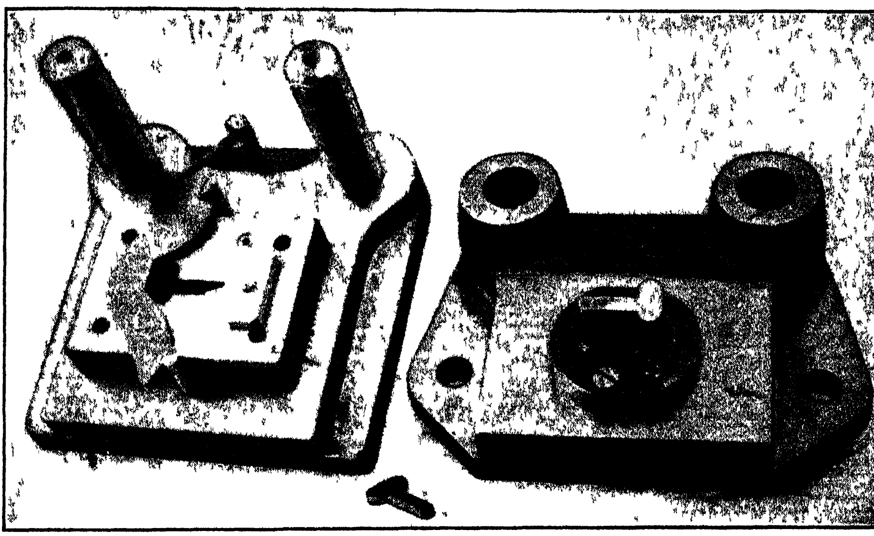


FIG. 17.—Shaving dies with open nest.

by the handle *M* for ejecting chips and a pin knock-out at *N* operated by a handle for lifting the finished work from the die.

Between the piercing tools and the shaving dies made to the same general design as the ones just described, there exist but few points of difference. The piercing dies are enough smaller than the shaving tools to allow the right amount of material for a satisfactory shaving cut which has been determined to be, for this thickness of work, 0.005 in. on each side.

SPECIAL FORM OF NEST FOR A THICK BLANK

In shaving blanks of unusual thickness the chip removed is likely to prove troublesome if the work is located in the customary form of nest, for it is usually impossible to provide sufficient clearance under the latter to

take care of the relatively thick, deep shaving removed from the contour of the blank. In such instances an open nest may be employed along the lines of the one used on the die in Figs. 17 and 18.

The shaving tools here represented operate on a half-hard steel blank $\frac{9}{64}$ in. thick, although the piece itself is only $1\frac{5}{16}$ in. long over-all. The

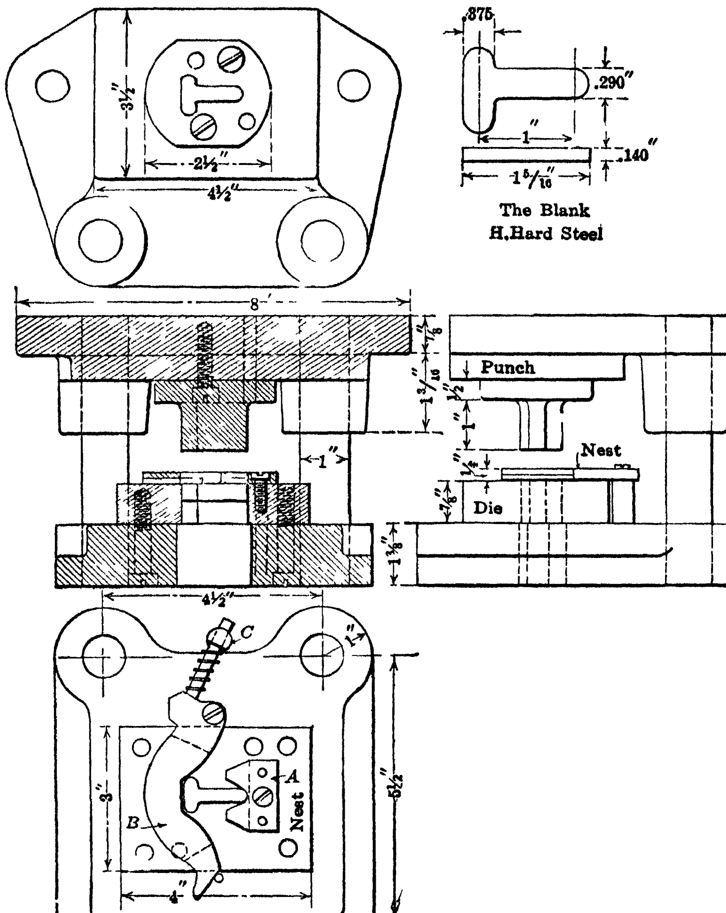


FIG. 18.—Construction of dies with special form of nest.

amount shaved from each side is about 0.010 in., and an enveloping nest would consequently be impracticable for the reason already noted. So the nest was constructed as shown, with a fixed V for locating one end and a swinging latch at the opposite end which is actuated by a spring to force the blank into central position over the die opening.

The two nest elements are shown at *A* and *B*, Fig. 18, the former with its narrow V notch for receiving the round end of the blank, the latter with

a wider V for centering the broad end of the work. The spring for controlling the swinging member *B* is compressed between the heel at the rear of the pivot, and a drilled post *C* secured at the back of the die base. Both parts *A* and *B* are cut away under side for chip clearance, as indicated by the dotted lines in the plan view in Fig. 18. The edge formed by this clearance cut acts as a stripper for the punch. The swinging arm or gate *B* allows the operator to keep the face of the die free from chips and to place successive blanks in position with ease and rapidity.

Other Forms of Dies

It will be noticed that all of the examples of shaving dies illustrated in this chapter are provided with guide pins or pillars to assure correct alinement of punch and die, which is an essential feature with such tools. This form of construction is in fact coming into general use in progressive shops for a large share of the press work handled in other classes of dies as well as in shaving tools.

The shaving dies in the preceding pages have all been shown as used for direct finishing of parts produced in some form of blanking die. There are, however, in different press rooms numerous cases where shaving tools are employed for operations on blanks that are passed through trimming dies before shaving or produced at the outset in trimming dies without preliminary blanking. Then, again, there are various interesting examples of shaving dies combined in one set with trimming tools so that the two distinct operations are performed in progressive fashion.

In the chapter that follows a number of trimming dies are illustrated and in conjunction with them several further types of shaving tools are shown.

Table 1.—Amount to Allow on a Side for Shaving Contour Where Only One Shave Is Taken

Thickness of blank	Soft steel	Half-hard steel	Hard steel	German silver	Brass	Thickness of blank
Inch	Inch	Inch	Inch	Inch	Inch	Inch
$\frac{3}{64}$ (0.0468)	0.0025	0.003	0.004	0.005	0.005	$\frac{3}{64}$ (0.0468)
$\frac{1}{16}$ (0.0625)	0.003	0 004	0.005	0.006	0.006	$\frac{1}{16}$ (0.0625)
$\frac{5}{64}$ (0.078)	0.0035	0 005	0 006–0.007	0.007	0.007	$\frac{5}{64}$ (0.078)
$\frac{3}{32}$ (0.0938)	0.004	0.006	0.007–0.008	0.008	0 008	$\frac{3}{32}$ (0.0938)
$\frac{7}{64}$ (0.1094)	0.005	0.007	0 009–0.011	0.010	0.010	$\frac{7}{64}$ (0.1094)
$\frac{1}{8}$ (0.125)	0.007	0.009	0.012–0.014	0.014	0.014	$\frac{1}{8}$ (0.125)

In the chapter that follows this section a number of shaving dies are described as applied to different classes of metal parts some of which have been trimmed closely to size in preceding operations.

TABLE 2.—AMOUNT TO ALLOW ON A SIDE FOR SHAVING CONTOUR WHERE A SECOND SHAVING OPERATION IS USED

Thickness of blank	Allowance for first shave			Allowance for second shave			Thickness of blank
	Soft steel	Half-hard steel	Hard steel	Soft steel	Half-hard steel	Hard steel	
Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch
$\frac{3}{64}$ (0 0468)	0 0025	0 003	0 004	0 00125	0 0015	0 002	$\frac{3}{64}$ (0 0468)
$\frac{1}{16}$ (0 0625)	0 003	0 004	0 005	0 0015	0 002	0 0025	$\frac{1}{16}$ (0 0625)
$\frac{5}{64}$ (0 078)	0 0035	0 005	0 006–0 007	0 00175	0 0025	0 003 –0 0035	$\frac{5}{64}$ (0 078)
$\frac{3}{32}$ (0 0938)	0 004	0 006	0 007–0 008	0 002	0 003	0 0035–0 004	$\frac{3}{32}$ (0 0938)
$\frac{7}{64}$ (0 1094)	0 005	0 007	0 009–0 011	0 0025	0 0035	0 0045–0 0055	$\frac{7}{64}$ (0 1094)
$\frac{1}{8}$ (0 125)	0 007	0 009	0 012–0 014	0 0035	0 0045	0 006 –0 007	$\frac{1}{8}$ (0 125)

Also the reader will find in the chapter referred to several dies in which blanks are trimmed and shaved progressively in two-stage follow operations

CHAPTER IX

TRIMMING TOOLS. DIES FOR TRIMMING AND SHAVING

There are several classes of trimming dies of widely varying design. Trimming is a term that applies to a number of distinctly different kinds of operations. Thus we have the trimming of the ends of cylindrical shells; the trimming of superfluous metal around the edges of drawn articles, especially where these are of irregular or unusual form of contour; the trimming of strip metal along the edges to produce blanks without resorting to conventional blanking dies; the trimming of ends or portions of a blank already produced or while still underway in progressive dies. The blank may require an unusually accurate dimension for a certain contact edge or point. This portion may either be trimmed exactly before the piece is blanked out completely, or a second operation may be adopted for trimming purposes while the blank is nested or otherwise located for trimming to definite relationship to an established working point such as a pierced hole or some portion of the edge of the blank.

In trimming the ends of drawn shells the "pinch-off" type of punch is often applied, especially in jewelry shops and in plants manufacturing cartridges for rifles and revolvers. The punch is provided with a shoulder which is kept sharp for cutting purposes, and the drawing die is finished with an abrupt radius which acts to assist the pinch-off shoulder of the punch to trim the end of the work neatly. Some toolmakers provide a slight 45-degree slope on the drawing radius to form a pinch-off seat.

General Advantages

Trimming dies, while of wide importance in the press shop, are not employed to anything like the degree that they should be, and in this respect their status is something like that of the shaving tools to which a chapter has already been devoted. Oftentimes their work is quite similar to the operations performed with shaving dies, although as a rule they differ from the latter in that they usually modify the shape of the work materially, or, if made to follow closely some portion of the contour, they are generally designed to remove a much greater amount of metal than is the practice with shaving dies, which, as already explained, are intended for taking a cut of a few thousandths of an inch only, at the most. Occasionally, shaving dies are used to finish some part of an object already brought closely to size by trimming; and the operations of trimming and shaving are sometimes combined in progressive types of tools for making

a piece complete from a strip of stock, which is first operated upon by the trimming dies to give the required outline at the edge, then advanced to the second position in the press where the shaving tools finish the trimmed portion, then advanced again for cutting off with a parting tool, after which each stroke of the press slide results in the production of a finished blank.

Trimming dies facilitate the production of many articles that it would be practically impossible to make in blanking tools alone or, if actually admitting of such treatment, would necessitate the employment of unnecessarily expensive and complex dies whose first cost and later upkeep would amount to an undesirable total. Again, where several different

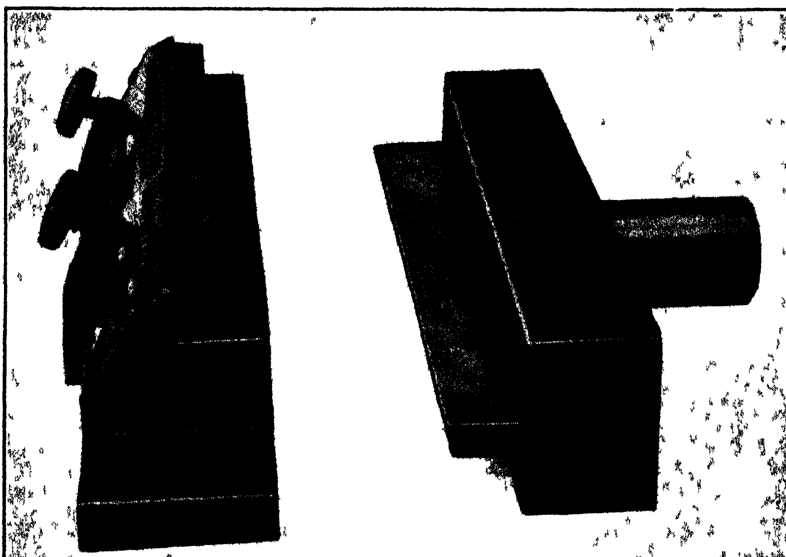


FIG. 19—Trimming tools.

parts are to be manufactured to the same form, but of varying width or length, involving ordinarily a set of blanking dies for each length of piece, the adoption of a trimming die makes it possible to blank all of the pieces uniformly in a single set of dies and then trim them to their individual lengths, thus eliminating the necessity for more than the one set of first operation tools.

SIMPLE TRIMMING DIES

In their simplest form, trimming dies resemble in construction and operation an ordinary shearing or cutting-off die; but usually, even when made for merely cutting straight across the work, they have their own peculiar features, particularly in reference to the means incorporated for locating the piece accurately in respect to other cuts already taken and for

holding the work during the trimming process. The latter feature, in fact, occasionally gives the trimming die a closer resemblance in appearance to a special fixture than to a press tool.

The photograph, Fig. 19, illustrates a case in point: This set of tools is for trimming the edge of a machine cover which has been passed through a number of press operations until its completion requires nothing further than the cutting off of the edge to a straight line a certain distance from the point where the bent portion meets the straight lip. The work rests on the die upon a stop surface at the left, which gives it the desired location in reference to the cutting edge, and it is here secured by two knurled head clamp screws while the sheared knife edge forming the punch cuts the metal straight across.

The sketch, Fig. 20, shows the manner in which the edge of the cutting blade is cleared for side shear and also the lengthwise slope which

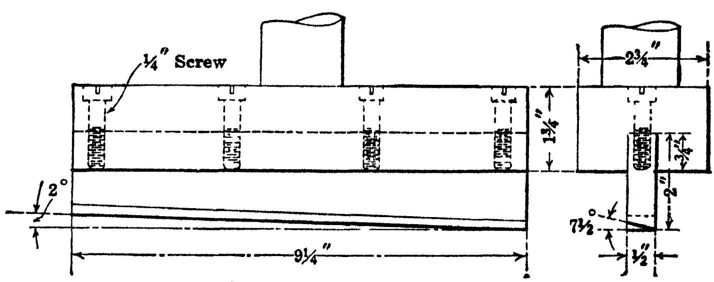


FIG. 20. Trimming tools.

gives the cut a shearing action clear across the work. The side angle is 7½ degrees, and the lengthwise slope has an angle of 2 degrees. The edge of the die or lower member of the set of tools is reduced to a width of about $\frac{1}{16}$ in. as seen in the photograph, to provide a concave clearance for an embossed surface formed along the work under the pierced holes. The cover trimmed with these tools is 9¼ in. long, and it is made from cold rolled steel 0.040 in. thick.

Progressive Piercing and Trimming Dies

A common application of the trimming principle for flat, blanked work is represented in the construction of the two sets of dies in Figs. 21 and 22.

Consider first the dies in Fig. 21; the work produced in these tools is shown in Fig. 23. It is a steel part about 3 in. long with a large opening pierced in the center and narrow lugs at ends and at one side. The die construction will be clear upon examination of Figs. 21 and 24. In the latter view the punches are shown by the cross-hatched sections on the plan of the die. The strip of stock and the work as trimmed are represented by the dot and dash lines. The strip is fed in from the right

and strikes the stop which is seen in Fig. 21. Figure 24 shows the work after the first stroke of the press. The two side punches A, B trim

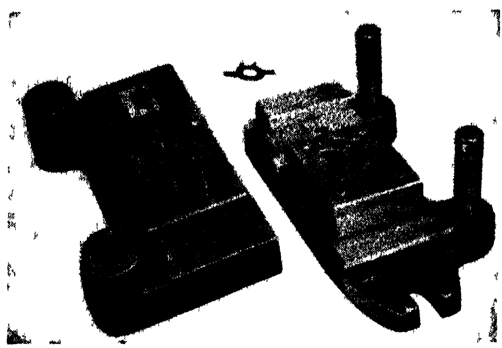


FIG. 21 —Trimming dies for producing a pierced blank.

out the opposite sides of the strip, leaving the narrow bar between two half circular portions for two adjoining blanks. At the same time the

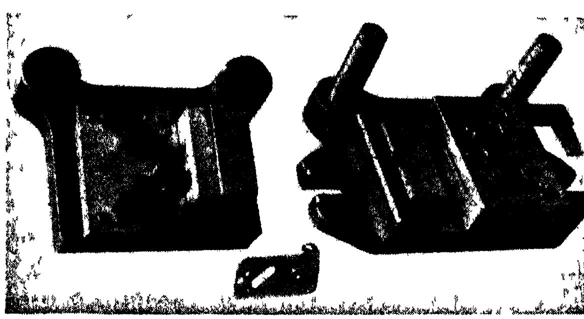


FIG. 22 —Dies for trimming and bending

side notch C is trimmed out of the leading end of the second blank. The hole pierced by punch D then forms the locating means for the pilot E on the cut-off punch when the stock is again fed forward. From now on, each stroke produces a trimmed and cut-off blank, the strip being fed against the shoulder on the die at F and then located as stated by pilot at E on the punch.

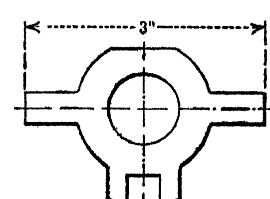


FIG. 23.—Blank made in dies in Fig. 21.

The trimming punches are finished with projecting ends below the cutting edges as indicated clearly in the sectional view Fig. 25, and piloting and guide portions are thus provided which extend through the stripper and into the die before the trimming cuts are taken. These supporting ends are customary with this type of punch wherever a cut of any length is required.

The dies in Figs. 22 and 26 produce the blank with bent ear shown

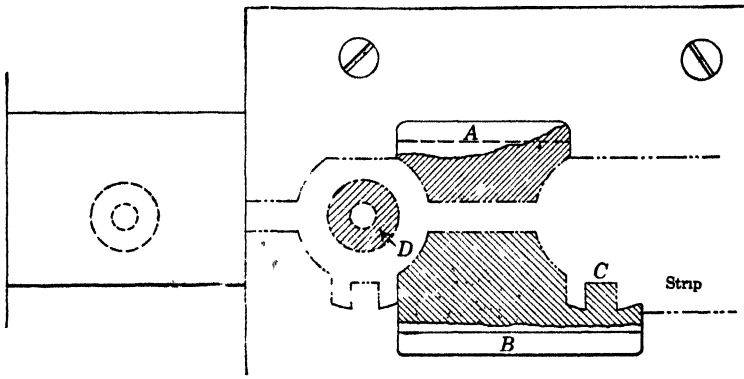


FIG. 24.—Plan of die for blank in Fig. 23.

in Fig. 27. These dies trim out the sides and form the round corners of the blank, pierce the small holes and elongated oblique slot, and then bend down the lug or ear with the same stroke that shears off the piece complete.

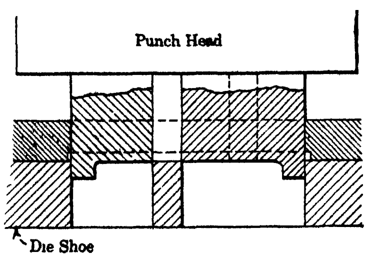


FIG. 25.—Showing trimming punch guided in die.

The first stroke trims out the round advance corners, E, Fig. 26, forms the projection F, and pierces the small hole in the projection. When the strip is fed to the second stop, all holes are pierced in the advancing blank while the trimming punches act on the rear end of the first blank and the leading end

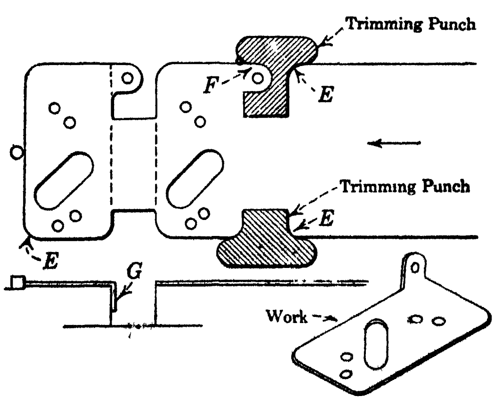


FIG. 26. FIG. 27.
FIGS. 26–27.—Trimming, piercing, and bending tools. See Fig. 22.

E of the next piece. The next position is against the pin stop, and the blank is sheared off, the cut-off punch having a relief at the back end to

form a bending portion to bend down the ear as at *G*. Each stroke then completes a finished piece.

The trimming punches here are also formed with guide extensions below the cutting edges to enter the die first and secure proper trimming action on the strip of material.

A Trimming and Shaving Job

A piece of work involving both trimming and shaving is shown in Figs. 28 and 29. This is a small steel cam with a radius from center to point of $\frac{13}{32}$ in. It forms an unusually interesting application of the trimming principle, for the blank is not made from sheet stock but instead

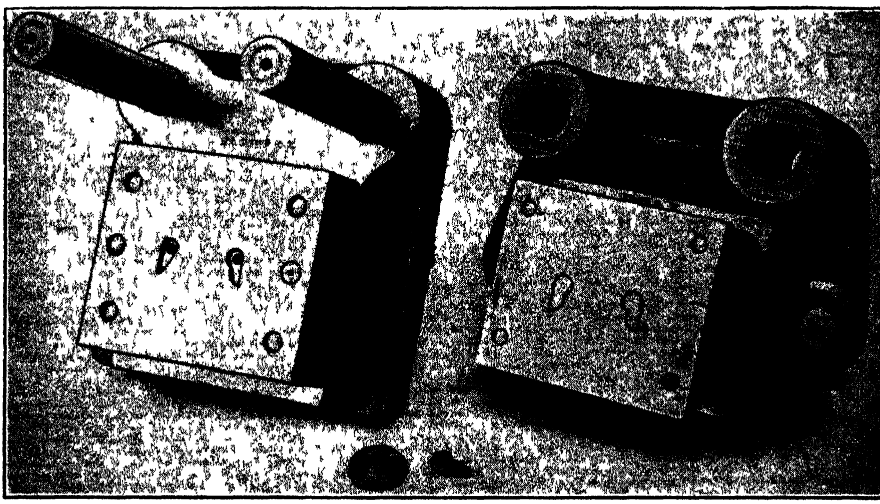


Fig 28 — Dies for trimming cams for a disk.

is produced in the screw machine where it is turned out to the form of a disk 0.080 in thick, with a hub finished to 0.280 in. diameter and a hole drilled and reamed through the center to 0.155 in. Thus in the shape of a thin disk it is passed through the press tools for the making of the cam contour instead of being finished by the more conventional process of milling to shape.

The cam is made both right and left hand. The dies are correspondingly made for right- and left-hand lobes, a duplication of die openings made necessary by the hub extending at one side of the cam. The disks are placed in the dies with the hub located in the round end of the opening, and the punch upon descending removes all of the superfluous metal around the cam by forcing the latter into the die. The cam is pressed down into the die by the punch to a sufficient distance to allow the next blank disk to enter hub down but with the lower face of the disk resting upon the face of the die.

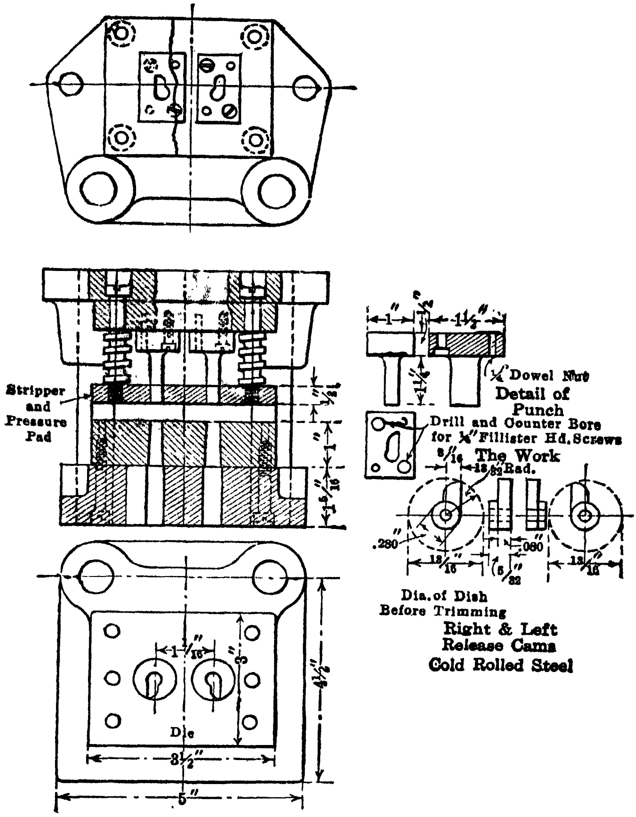


FIG. 29.—Trimming dies for a small cam.

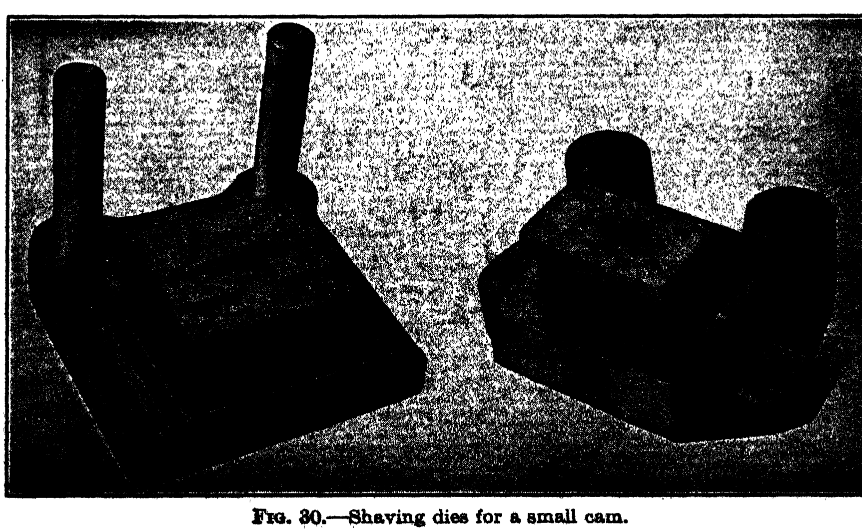


FIG. 30.—Shaving dies for a small cam.

The construction of the die is shown clearly in Fig. 30. The die openings are located at a distance of $1\frac{1}{16}$ in. apart to allow two blank disks to clear one another when placed for trimming and to permit of the punches being made separately with ample size of base for stability. The shape of the punches is seen in the detail, and it will be noticed that each is

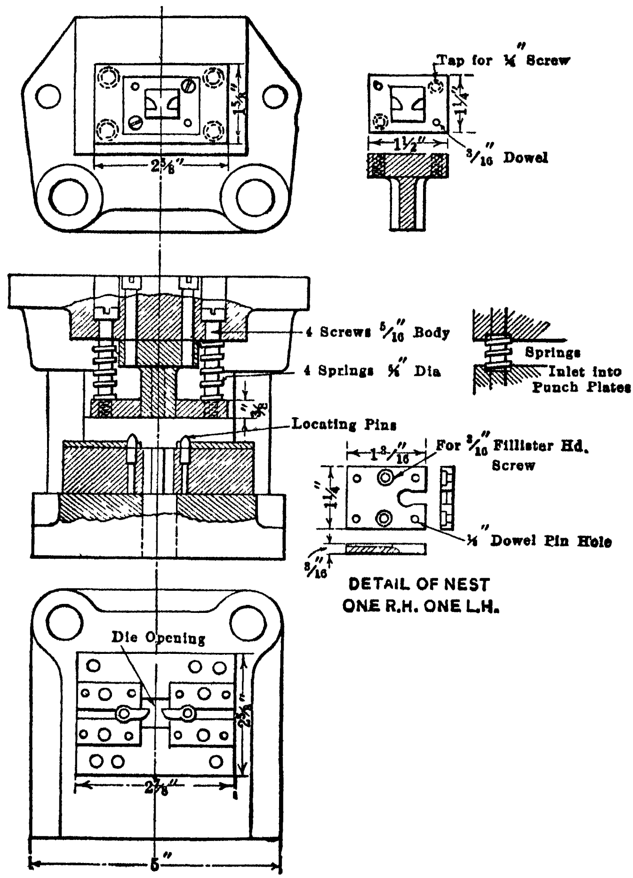


FIG. 31.—Details of cam-shaving dies.

made with a base 1 by $1\frac{1}{2}$ in. in area and secured by two $\frac{1}{4}$-in. fillister head screws and two dowel pins of the same diameter.

The pressure pad and stripper carried by the punch head is fitted closely to the punches and is normally held downward upon the work when the slide descends by means of four stiff pressure springs located at the corners on $\frac{5}{16}$-in. screws. The action of the springs and plate upon the up-stroke is, of course, to strip from the punches the trimmed-off portion of the disk left in the making of the cam.

Shaving the Cams

These trimming dies leave about 0.003 in. on a side at the point of the cam for finishing in the shaving tools, which are shown by Figs. 30 and 31. The die is made to shave two cam points at once, one right and one left hand, and the work is placed with the two points facing each other, in which position each cam is located with its reamed hole fitting over a pilot pin in the die face and with the cam body lying in a slot in the nest plate secured to the die.

The cam points are is positioned to allow a single punch with shaving edges on opposite sides to finish both cams at once.

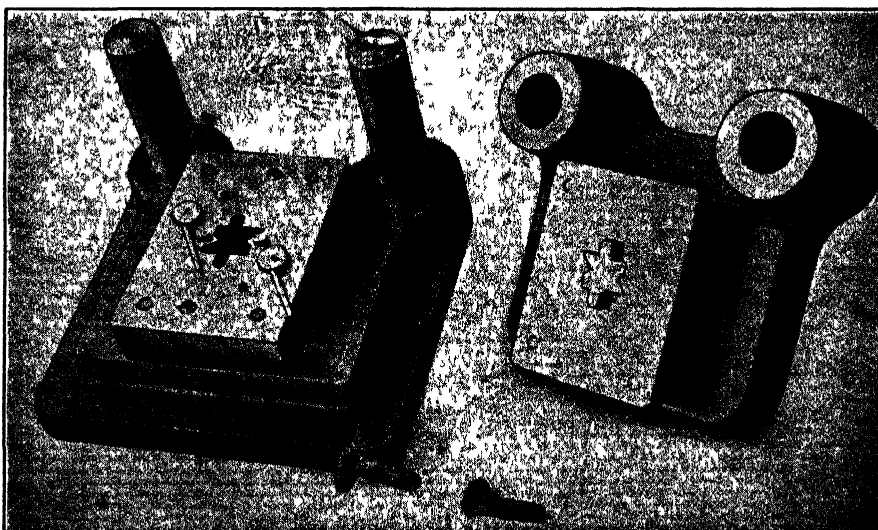


Fig 32 —Trimming and shaving cams for a small lever

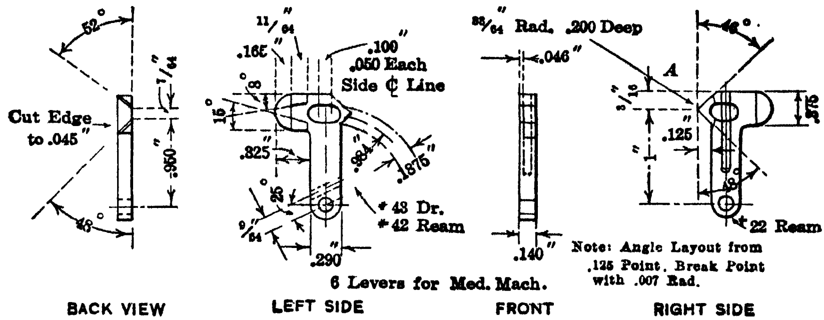
Details of punch, die nests, and pilot pins, spring stripper, etc., are all brought out clearly in the drawing, which should require no further description.

Like many of the tools illustrated in previous chapters, the trimming and shaving dies for the cams and those that follow are provided with guide pins or pillars for preserving truth of alinement with consequent accuracy and longevity in operation.

Another Trimming and Shaving Die

The steel piece in the foreground of Fig. 32 is another example of trimming and shaving work, which is shown in detail in Fig 33. This small lever, which is blanked from half-hard steel stock, is 0.140 in. thick, and prior to reaching the dies in Figs. 32 and 34 it has been shaved all

the way around and pierced in separate press operations. Both shaving and piercing dies are illustrated at another point (see Figs. 18, Chapter



Transfer Lever. 12 Req. .145 x 2¼" H. Hard Stock.

Fig. 33.

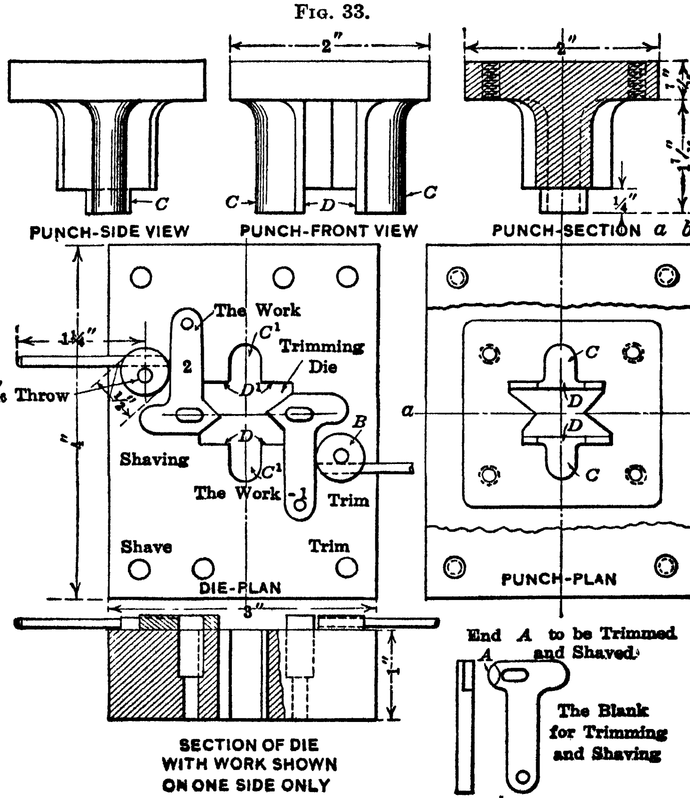


Fig. 34.

Figs. 33–34.—Trimming and shaving tools for a small lever.

VIII, and 105, Chapter III). The heel of the lever and the point have been milled down to dimensions given, and the object of the operations in the present dies is to trim the round end to an angle at *A* and shave it accurately.

The die is so made that the right-hand side of the opening, Fig. 34, is adapted for trimming the work to form the V point, while the opposite side is for the shaving operation, as indicated in the plan view. The blank, No. 1, at the right is shown as it appears after trimming; and the other piece, No. 2, occupies the shaving position. After the latter is removed the blank at the right side is transferred to the left, and a fresh blank placed in position 1 for trimming. Thus at each stroke of the press one piece is trimmed, and another shaved. The latter operation removes about 0.010 in. of metal from each side of the angular point.

FIG. 35 A piercing and trimming die

The method of holding the work at each side of the die is to slip it over two locating pins which fit the small round hole at the end and the oblong opening in the head of the work and then swing the eccentric binder *B* by the small handle to secure the piece in place.

The punch is illustrated in plan and by several elevations. It has two guiding extensions *CC* which are $\frac{1}{4}$ in. longer than the cutting face and which enter the corresponding guide openings C^1C^1 in the die to that depth before the cut is started. The shoulders *DD* fitting between sides D^1D^1 in the die still further steady the punch for the trimming and shaving cuts. The pressure pad or stripper fitted over the punch is controlled by four springs under the corners as shown clearly by Fig. 32.

Dies for Piercing and Trimming

Another form of shaving die combined with piercing tools is illustrated in Figs. 35 and 36 for operations on the two rocker arms shown in Fig. 37. These two steel pieces are blanked from $\frac{3}{32}$-in. stock and are alike as they come from the blanking dies. The trimming and piercing dies in these engravings are then used for piercing one-half of the lot

of rocker arms as at X, Fig. 37, and for trimming off and piercing the other half of the lot to make the shorter piece Y.

The drawing of the die and punch plate in plan view shows the method of placing two blanks at once in the nests on the die face, and the notation

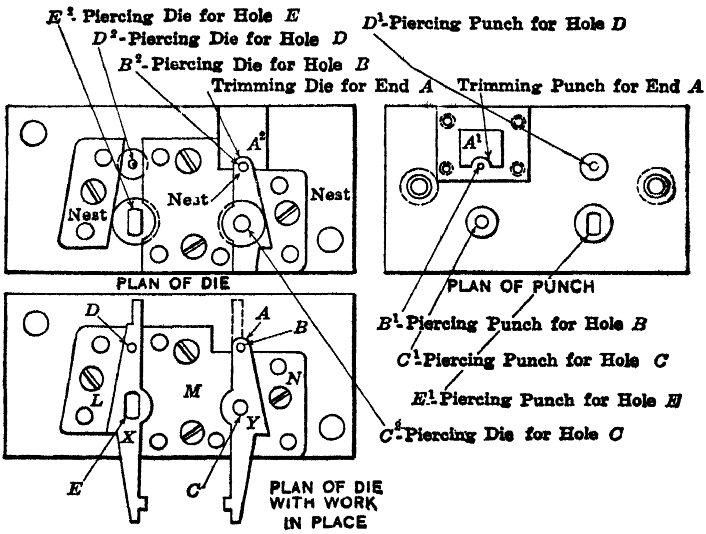


FIG. 36.—Trimming and piercing die.

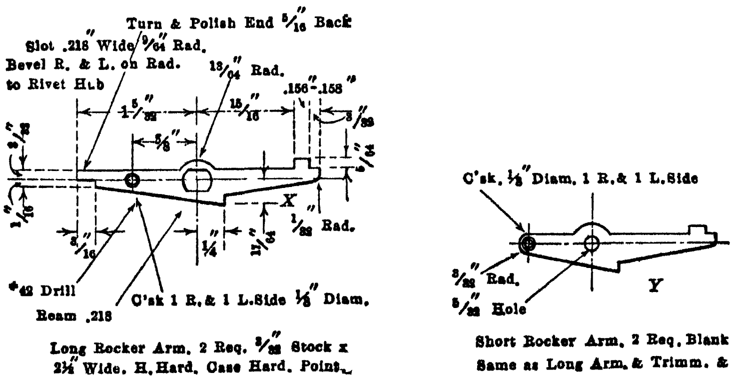


FIG. 37.—Rocker arm detail.

on the views indicates the operation performed by each punch and die in the set.

Thus the trimming punch A^1 trims off the end of one of the rocker arms at A, the portion removed being indicated by dotted lines. The punch B^1 and die B^2 pierce the hole B; the punch C^1 and die C^2 pierce the larger hole C. The rocker arm X at the left is pierced by punches D^1 and E^1 which act with dies D^2 and E^2 to form the holes D and E. The end of the work in this side of the die is not trimmed but is left to the blanked size.

The trimming punch A^1, it will be noticed, enters into and is guided by the slotted opening A^2 in the rear of the die. It performs its work before the piercing punches enter the blanks. The die hole B^2 for this end of the short rocker arm is formed in the trimming die itself, as shown by the half-tone, Fig. 35, but the other piercing dies are in the form of bushings which are inserted in the die plate where they are represented by dotted and full line circles.

The nests for the two pieces worked in these dies are made up of three plates L, M, and N, which are secured by screws and dowels to the die face. These nest plates are made to match the straight edges of one side of the work and the tapered edge on the opposite side. The wide center of the work is blanked to a radius of $\frac{13}{64}$ in., and this circular portion fits into a similarly shaped seat in the edges of the middle nest plate M to locate the piece endwise.

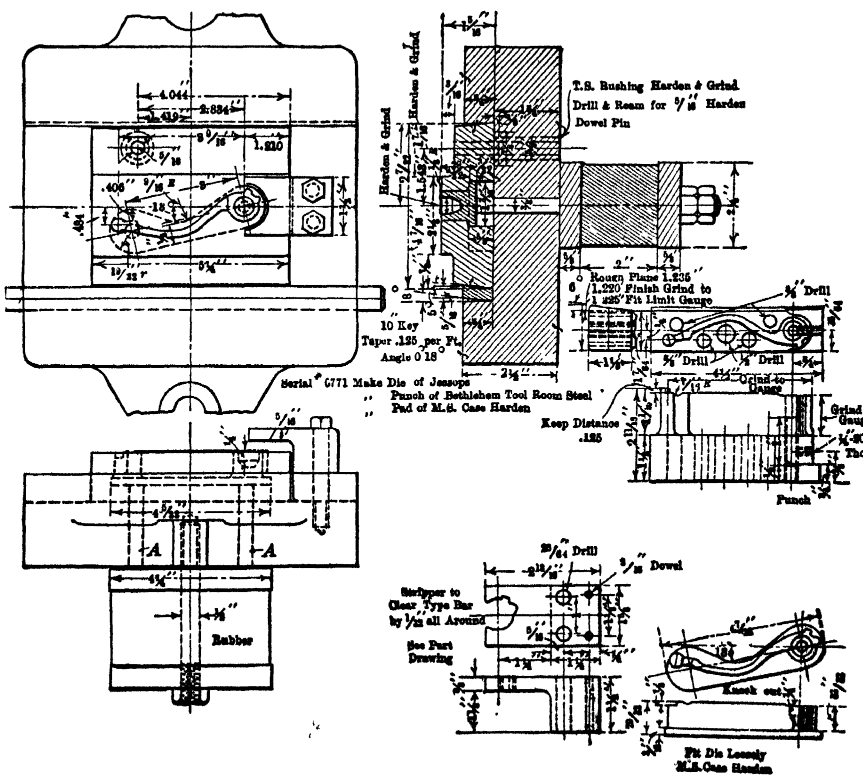


FIG. 38.—Trimming die for a curved part.

APPLICATION OF THE "KNOCK-OUT"

Where work of irregular outline and slender proportions is to be trimmed by forcing it down into a die, leaving the trimmed scrap or rim

on the die surface, it is advisable to use a knock-out to eject the trimmed piece from the top of the die to avoid possibility of the work becoming clogged or stacked in the die and injured by bending.

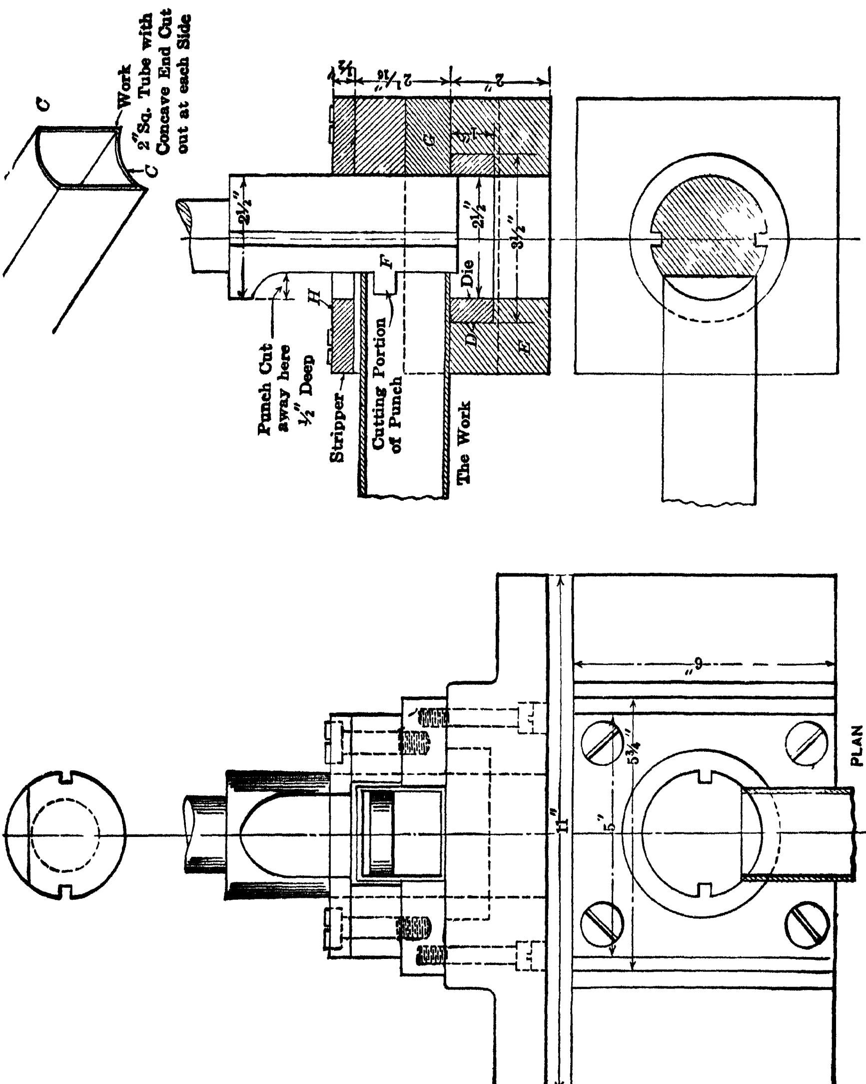


FIG. 39.—Trimming tools for a square tube

An illustration of a die of this character is presented in Fig. 38 herewith. It is for trimming a typewriter type bar which has a long, slender, and crooked body well adapted to give trouble in any effort to pass it through an open trimming die. So the die is made as illustrated with a knock-out which ejects the work after the trimming operation.

The outline and dimensions of the type bar will be seen from the drawing. The arrangement of knock-out and stripper is equally clear, but brief reference may be made to certain features. The knock-out is operated by a rubber spring of liberal proportions under the die base, and two pins at *AA* serve to connect the knock-out and spring. The knock-out is made to have $\frac{1}{32}$-in. clearance all the way around in the trimming die, and its flanged base fits up into the underside of the die as illustrated by the cross section. The stripper is an open end affair bolted to the right-hand end of the die.

Operations on a Tube

Sometimes dies are required for trimming the ends of round and square tubing where a half round or other shape of opening is wanted, and an example of a piece of work of this character is presented in Fig. 39.

The tube is of brass, 2 in. square, and requires a concave cut to be taken at each side as shown at *C*. This concave portion is formed to a radius of $2\frac{1}{4}$ in., and the depth of cut from the end of the tube is about $\frac{7}{16}$ in.

The trimming die consists of a die proper at *D* set into the shoe *E*, the die being made with a $2\frac{1}{2}$-in. opening to correspond with the diameter of the punch *F*. The block *G* is secured to the die shoe to carry the stripper *H* and is bored out to form a support for backing up the punch which slides closely in the guide bored in *G*. Block *G* is planed out to form a rectangular opening in front for the square tube to enter, and when the work is slipped into place it rests with its inner end against the flattened face of the trimming punch at *F*.

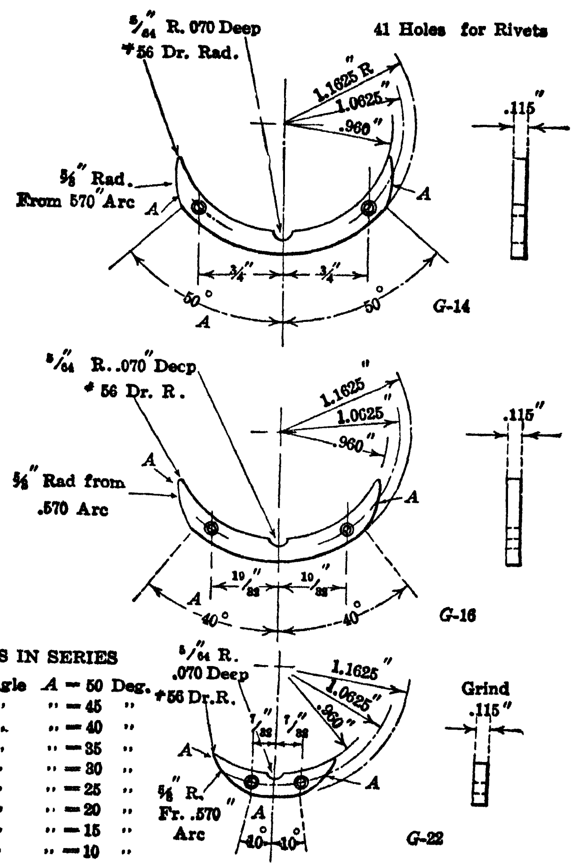
The punch is cut back for its entire length except for a portion about $\frac{3}{4}$-in. wide which is left with its original circle as a cutting edge for trimming out the concave end of the work. In operation the tube to be trimmed is placed as indicated with the flattened portion of the punchface for a stop, and then the lower side of the tube is trimmed to the desired concave. Then the tube is turned half over, and the operation repeated for the second side.

Adjustable Trimming and Shaving Dies

Reference has been made in the foregoing pages to the possibility of using trimming dies for cutting blanks of uniform pattern to different lengths in order to save duplication of blanking dies for each and every different size of piece in the series. An illustration of this principle is contained in the views that follow, which show the method of blanking, trimming, and shaving a set of nine steel cams for a business machine, these cams varying in length throughout the group of nine parts. Only one

set of blanking tools is required, and one second operation die accomplishes the trimming and shaving of the entire lot of cams.

Three of the set of nine cams are shown in detail in Fig. 40, and the table at the side gives the variation of all of the cams in the series as indicated by the number of degrees from the center line to the top of the cam riser near each end. Thus the range for the cams is from 50 down to



9 CAMS IN SERIES

G-14	Angle A = 50 Deg.	
G-15	"	" = 45 "
G-16	"	" = 40 "
G-17	"	" = 35 "
G-18	"	" = 30 "
G-19	"	" = 25 "
G-20	"	" = 20 "
G-21	"	" = 15 "
G-22	"	" = 10 "

STEEL CAMS

FIG. 40.—Details of three cams of a set of nine.

10 degrees as measured from center to point of throw. The cam ends at the arc A are all alike, and this arc is struck from a radius of 0.570 in. in all cases. This makes it possible to utilize one trimming die for all sizes of cams, as the portion operated upon in finishing the blank is uniform throughout the series of cams.

The blanking tools are seen in Figs. 41 and 42, and the latter shows the method of locating the stock gage so that it drops into the opening in

the scrap immediately ahead of the blank that is being punched out. The stop is of the trigger type with projecting end for operation by the adjust-

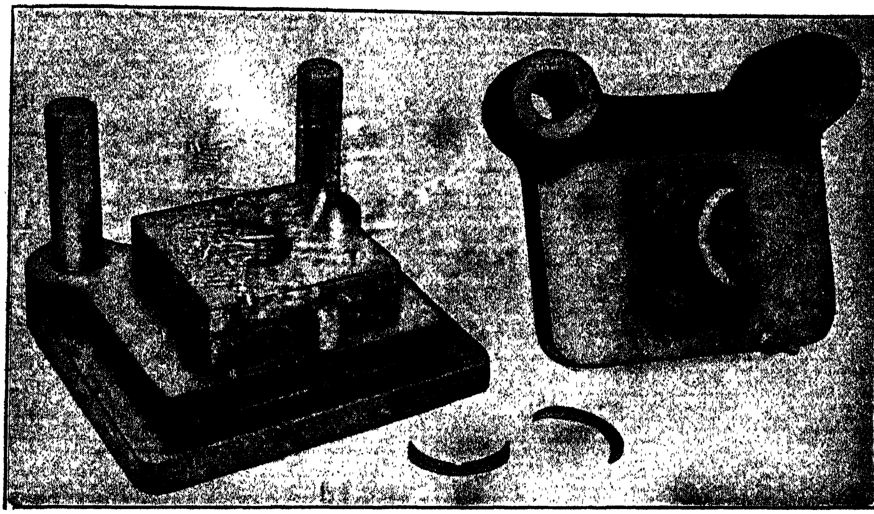


FIG. 41.—Cam-blanking dies.

able striking screw in the punch head when the latter descends. At the right is a spring-actuated pressure finger for holding the heavy stock

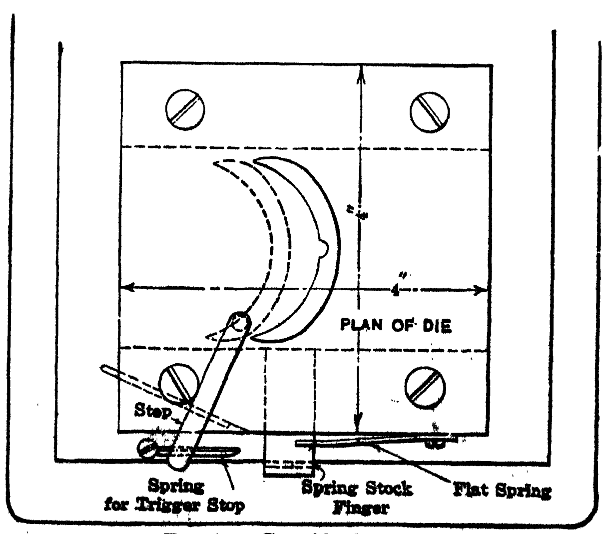


FIG. 42.—Cam-blanking die.

closely to the back guide under the stripper. It will be noted that this stock is 0.120-in. half-hard steel.

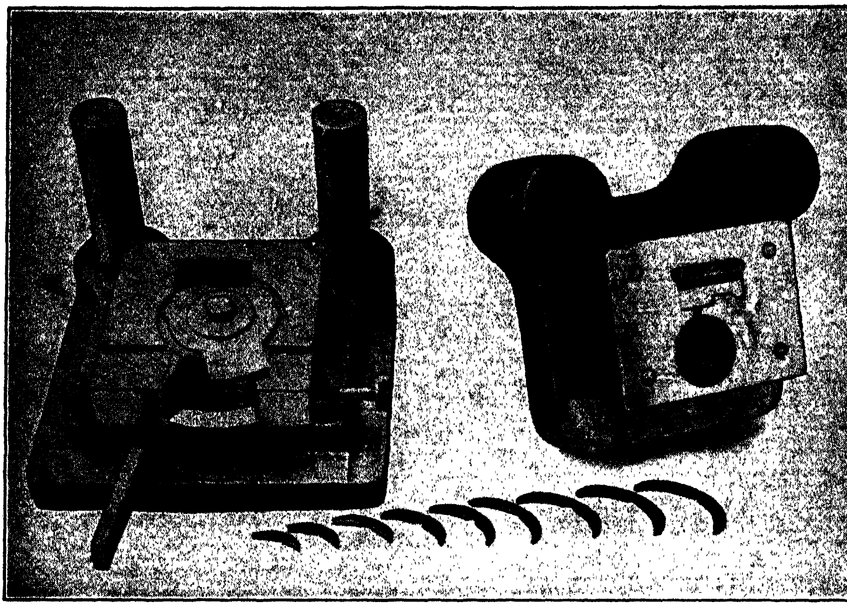


FIG. 43.—Trimming and shaving dies for a steel cam.

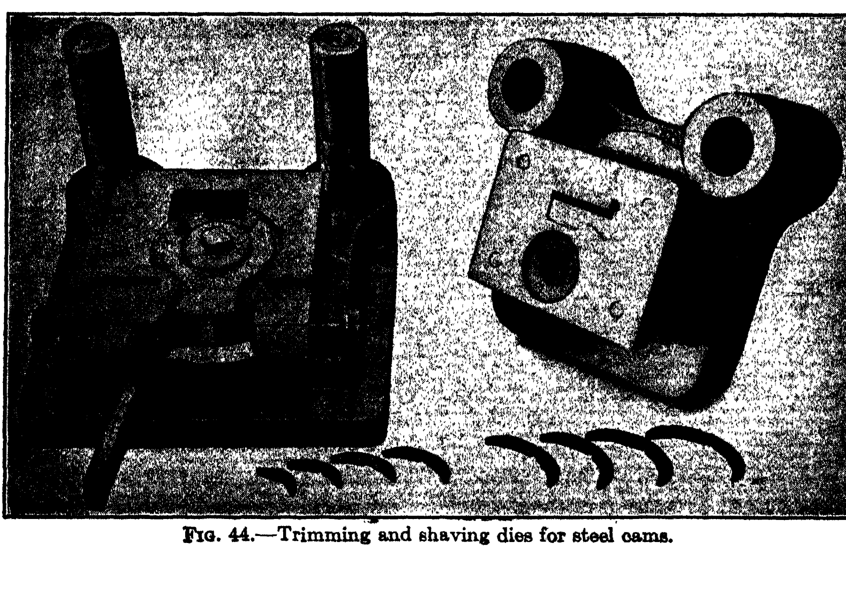


FIG. 44.—Trimming and shaving dies for steel cams.

Construction of Trimming Die

The trimming dies (which are also used for the shaving operation) are shown by Figs. 43 to 48 inclusive In the first of these views the entire series of nine cams of different lengths are shown in the foreground, and the locating nest is seen empty with three knock-out pins projecting slightly above the bottom of the work seat just as they are thrown up by the handle in front when the trimmed cam is ejected. In Fig 44 the

Fig 45 —Face of cam die

middle length of cam—No 18, as it is called—is seen in position in the nest which is here shown adjusted around to central position. In the preceding view, Fig. 44, this locating nest is seen at the extreme right-hand position or in the place in which it is set for the longest cam of the series, namely, No. 14. In Fig. 45 the graduations at the front of the die for giving the nine positions for all of the cams are plainly seen.

It will be gathered from these views that this die is arranged to take the same cut on all of the cams, that is, to give the ends of all cams the same form; but each number of cam is cut to a different length from the other cams in the series, so that more metal is trimmed off from some

cams than from others, the amount removed varying with each cam member.

With reference now to Fig. 46, this drawing shows at A a half-round lug on the locating device B which is used for positioning all lengths of cams from the similar notch blanked in their concave sides. According to the detail, Fig. 40, this locating notch is made to a radius of $\frac{5}{64}$ in. and

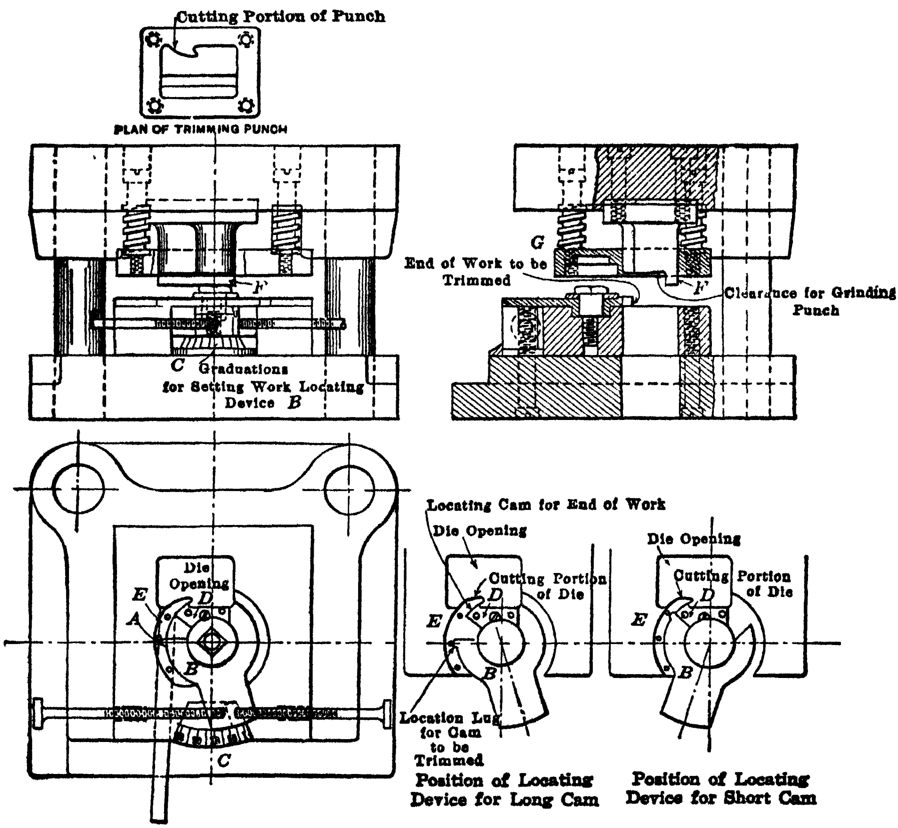


FIG. 46. FIG. 47. FIG. 48.

FIGS. 46–48.—Trimming and shaving dies for steel cams.

is 0.070 in. deep. When the adjustable nesting device B is set by the front graduations C to the right position, the cam placed in the nest will be cut off to desired length and form. After the entire lot for one length of cam has been trimmed, the device B is reset to another graduation C, and the next length trimmed, and so on. This is brought out distinctly by the sketches, Figs. 47 and 48, which show the settings for two cams, one long and one short, and indicate the amount of movement of device B in the change from one cam to the other. The intermediate settings

possible are all established by the graduations on Plate C let into the front of the die shoe.

The Cutting Edges

The front end of any cam trimmed in this die is located against stop gage D, and as the blank cam rests closely in the circular channel or nest E with its half round notch over the lug A, the work is well secured against shifting under the cut. This notch, by the way, is the locating medium for the finished cam when assembled in the calculating machine, hence the importance of finishing all ends from this central point. Both ends of each cam are trimmed alike, the blank being turned over for the cut on the opposite end.

The trimming punch has only a short length of cut but is itself of liberal proportions for rigidity. It fits at back and sides in the oblong die opening which acts as a further guide for retaining the punch in alinement. The back of the punch as indicated at F is $\frac{1}{4}$ in. longer than the face so that it has an opportunity to become well located in the die opening before the cutting edge strikes the work. The punch is enclosed in the spring-controlled stripper and pressure pad G which holds the blank firmly during the trimming operation.

In operation, the die is first set for trimming the cams to specified length by bringing the vertical zero line 0 (on the wing under locator B) to within $\frac{1}{32}$ in. of the required graduation on scale C. This offset is enough to allow the dies to trim the cams longer than finish size by about 0.010 in. which amount is left for shaving in a second operation in the same dies. For the shaving cut, which is taken after the entire lot have been trimmed as above, the locating device B is reset exactly to the requisite graduation, and the work run through as before for the removing of the thin chip which smooths the cam ends perfectly and brings them to exact length.

Trimming and Shaving Dies of the Progressive Order

There is one more type of die that should be of interest in this chapter —the progressive trimming and shaving arrangement illustrated by Figs. 49 and 51. These tools are for the manufacture of a small machine key of the dimensions given on the part detail in the last engraving. The material used is steel lengths about $\frac{1}{2}$ in. wide by 0.078 in. thick. The dies perform their work by cutting away the material from one side only, thus producing the piece complete by the trimming and shaving process.

The small key is finished 0.458 in. long and has a projection at one side 0.015 in. high by 0.090 in. wide. The method of running the stock

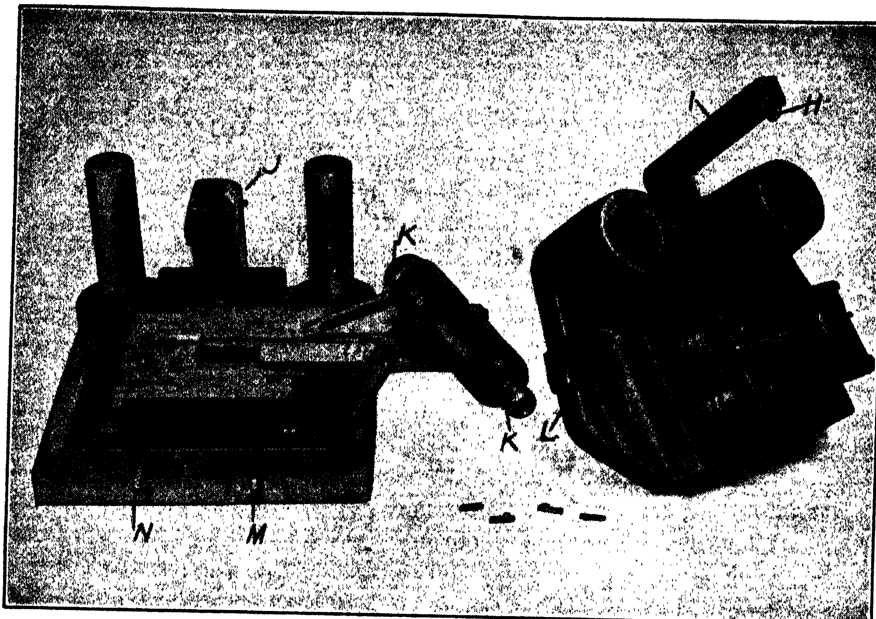


Fig. 49.—Trimming and shaving dies in progressive order.

Fig. 50.—View of punch and die face.

through the dies will be understood upon examination of the plan views of the tools in Figs. 50 and 51.

The material is fed in through the narrow channel guide at the right of the die openings, and with the first stroke of the press the trimming punch A takes a cut along the edge indicated at A^1. At the next advance of the stock, the portion already trimmed is shaved as at edge B^1 by the punch

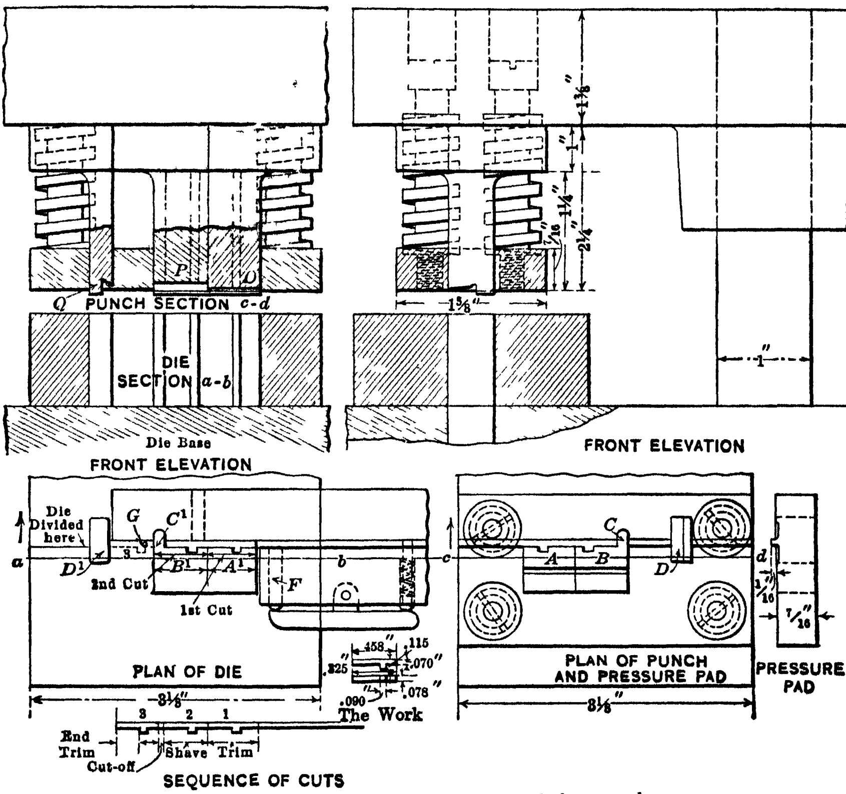


FIG 51.—Progressive trimming and shaving die.

B, and the trimming punch A operates on the next cut. At the same stroke, the extension C on the shaving punch B cuts off the key at the point C^1, and when the work is advanced to the third position the end of the key is trimmed by the punch D and die D^1. Each succeeding stroke of the press then causes one portion of the stock to be trimmed closely to the key width, the preceding portion to be shaved to size and cut off, and the leading end of that piece to be shaved to length.

Some Details of Construction

The drawing, Fig. 51, shows the principal features of the tools, but certain details are best seen in the photographic views, particularly the air

nozzle and control for blowing the finished blank from the dies. The narrow strip of stock is pressed back to the guide by the spring-actuated finger *F* at the front, this being shown by dotted lines in the plan view of the die in Fig. 51. At *G* is a small knock-out pin which is operated by a wedge-shaped member underneath to lift the finished work slightly and so allow the compressed air charge to blow the piece clear off the dies. The wedge for operating this is itself moved forward against spring pressure by a pivoted latch *H*, Fig. 49, which is carried on a vertical arm *I* adapted to operate in tube *J* at the rear of the die. The pivoted piece *H* on the down-stroke rocks up sufficiently to swing past the end of the operating wedge, and on the ascent of the punch it drops back to its seat and acts against the end of the wedge which then slides forward and operates the knock-out pin *G*, Fig. 51.

The air nozzle is controlled by the plunger *K*, Fig. 49, and the hooked finger *L* on the punch head which acts upon the plunger head when the punch rises with the press slide. The stop for the first position of the stock is operated by lever *M*, and the second stop by lever *N*.

The Form of the Punches

The different views show clearly the form of the punches and stripper, as well as the die itself which is made in halves to facilitate construction. The trimming and shaving punches *O* and *P* are of different height of cut so that the trimming tool does its work before the shaving die strikes the stock. Both punches, and the end punch *Q* as well, are made with back portions extended downward sufficiently to enter the guides formed by the die openings before the cutting portion contacts with the work. The cutting edges are cleared as shown, and the relief along the center of each punch end enables the tools to be ground readily.

Another set of dies of this same construction are used for trimming and shaving a longer key, and here the punches are sheared from end to end to enable them to take the longer cut easily and with smoothest possible results. The shearing angle on these cutting edges is about 3 degrees.

The pressure pad and stripper for the punches shown is backed up by very heavy springs at the four corners, and the pad face is milled away as represented to leave a narrow bearing surface along the face for contact with the work. This holds the narrow stock strip securely against possibility of rocking during the taking of the cuts along the one edge.

Section IV

DRAWING PROCESSES AND TOOLS

CHAPTER X

DRAWING DIES AND DRAWING METHODS

We quite commonly think of the drawing process as one in which round or cylindrical work such as shells, containers, and similar articles are produced from the sheet stock, although actually the parts so made include a variety of objects hardly exceeded in number by those produced by any of the other stamping processes.

Drawing presses produce at one end of the great range of items thus manufactured very small objects such as eyelets, cartridge primers, and small cartridge cases; at the other extreme the modern giant press draws up automobile body parts and tops and other work of very large proportions. Between these extremes of capacity thousands of presses in our different factories are drawing about every conceivable form of article in great numbers and from every kind of sheet metal that is suitable for the purpose.

Many classes of work formerly produced from solid stock in bar form or finished from forgings have been transformed into press products drawn up from sheet stock of proper gage for strength and stability, and usually this has been accomplished with important saving in material and labor.

Unusual Forms

The stamping in Fig. 1 is an irregularly shaped piece forming part of a lubricant container with deep drawn pocket of half cylinder form made by drawing a chamber in an oblong blank which is sheared from stock of proper width before going to the drawing dies. Following the operation here the blank is trimmed, perforated with a number of small holes, and formed into a rectangular case ready for reception of a closing plate or cover.

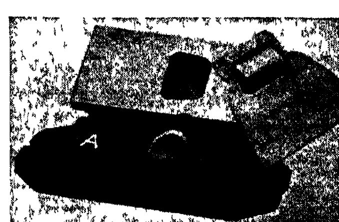


Fig. 1.—A drawn receptacle. Drawing pad *A* operated by pressure pins on spring pad below press.

An example of a very large stamping job is the Budd "Mono Roof Body" part shown in Fig. 2, with the big press in the background. A description devoted to large automobile body dies is included in another section.

These views are included here to illustrate some of the many classes of work handled in drawing dies. The different shapes so produced are

practically endless in number. Square, rectangular, and other geometrical forms are drawn up into boxes, containers, utensils, etc. The greater portion of the sheet metal parts used in manufacture of ranges, refrigerators, cabinets, lockers, metal furniture generally, and an infinite variety of other products are fabricated by means of press tools, and in many instances these tools are for drawing the work into some special form of more or less complicated outline.

Deep drawing of cylindrical articles presents one class of problem to the die shop, and drawing of irregular patterns brings into use an entirely different set of factors. In most cases the suitability of the material to be worked has to be taken into consideration, and usually

FIG. 2.—Big press work. Drawing auto-body top

the material must be selected according to the project under way. In many classes of smaller parts where shallow drawing hardly more than forming is to be done, less difficulty is encountered in working the metal as required; though even with small work where particularly smooth corners are essential attention must be paid to selection of stock that will admit of drawing without undue pressure on the blank. Discussion of such points as the foregoing will be carried along with other details as this section is developed through the following pages.

The subject of drawing dies is extensive and has far-reaching possibilities. No matter how many illustrations are presented to show diversified applications of the drawing process it is impossible to bring more than a reasonable number of cases to the reader's attention. It is to be hoped that the examples shown will be sufficiently varied in

character to give some clear picture of basic principles and practical application of these principles in respect to design of dies and in regard to the class of work to which they are adapted.

Action upon Materials

Press tools of this class, while used in almost infinite form and variety, are frequently found to be most difficult to make for entirely satisfactory operation. There are several factors entering into their use that have less weight with other classes of dies and which cause each set of drawing dies to be more or less of an individual problem for the tool maker.

In the first place, the character and quality of the material to be worked are elements of greater importance than with the majority of press tools and a set of drawing dies which might give perfect results with one grade of stock may be found anything but satisfactory when applied to another kind of material. The thickness of the metal is another factor that must be given unusual consideration for it has a most direct bearing upon the form that is to be given the edge or mouth of the drawing die, the radius of the corner at the drawing edge being usually based to a large degree, if not wholly, upon the gage of the stock to be drawn.

The division of the total length or depth of draw into a suitable number of intermediate operations is another feature of the problem. A shallow draw is one proposition; a deep draw another. The character of the metal worked is a determining factor here and the total number of draws and the corresponding number of tools in the entire outfit is a matter that is quite apt to be settled in accordance with the experience of the die maker who has the work in hand. With his knowledge of the limitations of various grades of stock he is enabled to arrive at results that cannot, as a rule, be obtained by merely following a layout that may or may not seem properly proportioned.

Limiting Factors

If the attempt be made to draw the metal to too great a depth in each operation the material will be fractured or the bottom of the shell torn out. If the radius of the drawing die edge is too small the metal will be drawn too abruptly over the corner with probability of becoming stressed beyond its tensile strength and ruptured. If, on the other hand, the radius be too great the surface of the work is likely to become wrinkled in the drawing process due to the failure of the material to cling to the drawing surface. With the heavier gages of stock there can be corresponding increase in the radius of the drawing edge because of the tendency for the thicker metal to hold closer to the drawing surface.

If too little allowance is left between first operation drawing punch and die diameters, unsatisfactory results may be expected, for in such case the

shell is likely to be fractured, and the wear on the die surface seriously increased, with the result that it becomes scratched and pitted through consequent improper lubrication, and the work is drawn with a scratched surface. If the depth of the drawing surface in the die is too great similar results will be produced. These are some of the considerations affecting punch and die construction for drawing operations, and they will be dealt with more fully, along with other features of importance, as this chapter develops.

Action of the Tools upon the Work

It is not always easy to analyze the action of drawing dies and the detailed effect of the drawing process upon the material. The following sketches may be of aid in this direction however.

Suppose we have, for example, a 3-in. disk of brass, *A*, Fig. 3, which is to be drawn in a single operation (for simplicity of illustration) to the shell form at *B*, which has a depth of $1\frac{1}{4}$ in. and a diameter measured at the center of the thickness of the wall of $1\frac{3}{8}$ in. These are the proportions to which such a blank would draw if no allowance be made for stretch in the stock and if the corners were square. Now let us consider what the combined effect of the punch and die will be when the round blank is pushed down through the die, or "drawn," as we say, into the shell *B*.

The punch we will consider as made smaller than the inside diameter of the die, by an amount equal to twice the thickness of the metal to be drawn, so that the latter will have space to retain its original thickness. The central portion of the blank, then, for a diameter equal to the size of the die opening, will be started down into the die much as though it were being punched out by a piercing punch except that the round corners of the punch and die and the liberal side clearance between the two tools will prevent the center from being cut out, and, as the punch continues to descend, all of the metal in the blank surrounding the central portion will be caused to follow down through the die and, in doing so, to flow along radial lines until the complete area of the ring of stock outside of the center which forms the bottom of the shell has been absorbed into the side walls of the shell.

Displacement of the Metal

The effect of this drawing process upon the structure of the blank disk of metal may, to a limited extent at least, be seen by reference to Fig. 4. Suppose that here we have placed a number of narrow strips of stock, *C*, *C*, *C*, which are of so light a gage that their thickness may be disregarded for the moment. These strips are spaced uniformly in a seat or nest at the top of the die and their width is such that their edges intersect at a dis-

tance from the center equal to the radius of the die opening below, which is here indicated by the dotted circle *D*. The punch is then allowed to

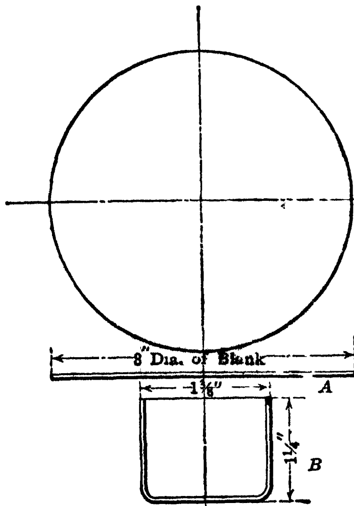


FIG. 3.

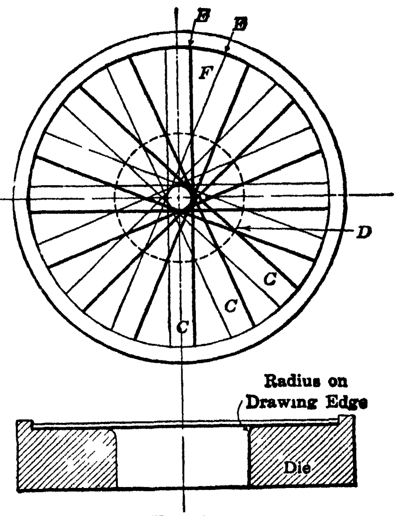


FIG. 4.

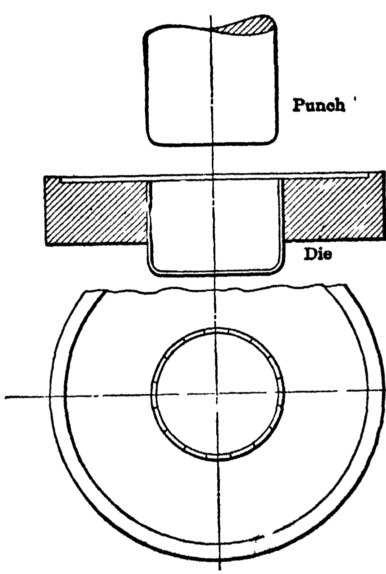


FIG. 5.

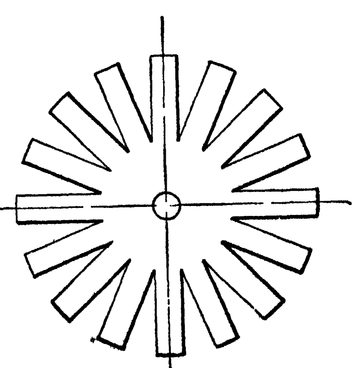


FIG. 6.

FIGS. 3–6.—Action of drawing dies.

descend and in so doing it forms up the series of crossed strips of metal into the shell in Fig. 5 where the vertical walls of the piece are composed of the formed up ends of the strips which are shown as abutting against

one another. As these strips are bent down over the drawing edge of the die and pressed down through, their ends approach the die diameter, and, traveling along radial lines, their facing corners *E*, *E*, converge and the triangular space *F* between them grows smaller until it disappears completely with the arrival of the ends of the strips at the die opening upon the completion of the down-stroke of the drawing punch.

Application to the Solid Disk

If we now transfer the pattern made up of the narrow strips in Fig. 4 to the plain disk, Fig. 3, and trim out the V sections between the lines, we obtain a spider effect, Fig. 6, with a center the size of the die and sixteen radiating arms. This blank may then be forced through the dies and formed into the same shape as the crossed strips, or again as represented by Fig. 5. But the process is not one of drawing, for no metal has been displaced or caused to flow under tension, and the shell wall formed by the series of vertical arms on the blank is merely the result of a forming or bending operation accomplished in the drawing die.

But, upon taking the plain disk, Fig. 4, and comparing its area with that of the spider in Fig. 6 and then forcing the former through the drawing die we are enabled to arrive at some conclusion as to the effect upon the blank under the drawing process. In this particular instance, the amount of material cut out of the blank in Fig. 6 will equal about 2 sq. in. or roughly 30 per cent of the original area of the plain disk. Therefore if this plain disk is drawn up as in Fig. 3, the above area of 2 sq. in., times the thickness of the stock, is the amount of metal that has to be displaced by the flowing under tension and absorbed into the mass of the shell during the drawing operation.

The 30 per cent of material thus accounted for represents an exaggerated condition, in order that emphasis may be placed upon the peculiarities of the drawing process; under usual practice the first drawing operation, or the "cupping" so-called, from the blank to the first short shell or "cup" is not designed to produce a height of side wall of much over one-half the diameter of the shell, especially if the metal is $\frac{1}{16}$ in. or more in thickness. Therefore, if in approaching more closely to normal conditions we cut down the diameter of the blank to, say, about $2\frac{5}{16}$ in. (which would be the approximate size for a shell drawn to $1\frac{3}{8}$ in. diameter by $\frac{5}{8}$ in. high) we shall find that the excess of metal to be absorbed into the body of the shell as drawn through the die is only about one-half the above proportion, or 15 per cent.

The Lines of Movement

As already pointed out, the flowing of the metal in the blank disk, when subjected to the tension imparted by the drawing tools, is, generally

speaking, along radial lines; although there would necessarily appear to be an accompanying lateral or annular flow throughout the body of the shell, particularly where the punch and die are so made as to leave a space between their surfaces equivalent only to the thickness of the stock. The result is a more densely compressed material with corresponding hardening of the metal which necessitates a resort to annealing processes before redrawing of the shell may be satisfactorily accomplished.

In reference to this allowance between the diameter of the punch and the inside wall of the die, it has been found desirable, particularly with first operation or cupping tools, to exceed the thickness of the metal to be drawn and allow from $2\frac{1}{4}$ to $2\frac{1}{2}$ times the stock thickness between punch and die diameters. A good many shops working on steel shell operations follow the practice of making drawing dies with only enough clearance between punch and die for the double thickness of material. In contrast with this custom, some most successful tools for cupping and several redrawing operations have been made for heavier work with the drawing die $\frac{1}{32}$ in. over size. This gives a die that works easily and which is not likely to become quickly scratched. The work drawn up is more easily ejected and where a close degree of uniformity of wall thickness is not essential the tools are operated with entire satisfaction. The material naturally is not subjected to such high stresses with the larger dies, and it will usually be found practicable to pass the work through an increased number of operations before annealing. Furthermore there is a tendency for the walls of the work to thicken up under these conditions which is a feature of value where increased strength is desired. And, the tools themselves being subjected to less severe service, are capable of correspondingly increased production.

The Drawing Edge of the Die

The drawing process starts with the forcing down of the material over the edge of the die and it is at this point that difficulty is likely to commence, either with wrinkling of the work or in fracture of the shell as it is drawn down through the die. As stated in the opening paragraphs, too small a radius at the drawing edge, too sharp a corner, puts the material under undue stress and may lead to rupture; although this radius should be held to a low dimension when an even-ended shell is to be produced in a single operation. As the radius of edge is generally established for a given material by the thickness of the stock, the radius for thin material may be quite small. Some die makers recommend a rule for fixing the radius at from six to ten times the thickness of the material, but even this allows a wide latitude for individual judgment and there are numerous instances where considerable departure must be made in one direction or the other from the above suggestion.

The simplest type of blanking outfit, one for first operation, the production of a shallow cup from a round disk, is represented by Fig. 7. The die in this instance has a seat, or nest for the reception of the blank disk, and the nest surface and die opening are connected by the liberal round corner indicated so that the material will draw down readily into the die. When the punch has completed its downward movement and commences to rise the shallow cup is stripped from the end of the punch by the sharp lower edge of the die and falls out of the press.

This form of die is suited only to the making of shallow draws for it carries no pressure plate or blank holder to apply pressure to the surface of the material and so prevent wrinkling of the work as it is drawn down over the die edge. The use of the pressure plate is an essential for general drawing operations as it "irons" out the surface of the work between its face and the opposing face of the die to eliminate wrinkles in the metal. The degree of pressure applied to the material must, however, be regulated with judgment, otherwise the metal will be strained unduly in passing over the radius of the drawing edge of the die and this may lead to the work breaking when passed through subsequent operations.

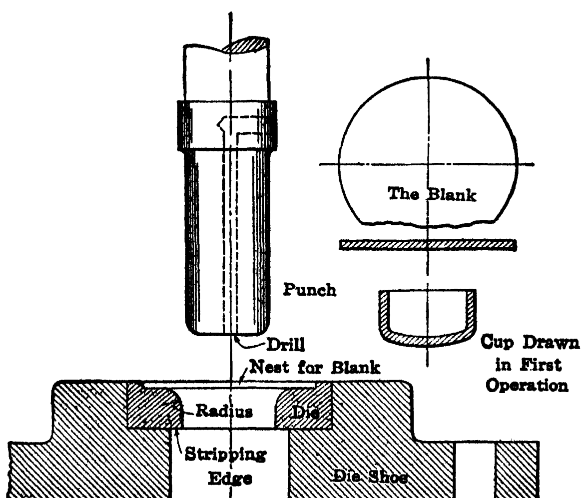


FIG. 7.—Typical drawing-die construction.

General Types of Drawing Dies

Besides the simple form of die illustrated in Fig. 7 there are a number of types that are used extensively, some of them of a relatively complicated character. In contrast to the non-blanking dies just referred to, they are commonly constructed to cut their own blank and perform the first drawing operation at a single stroke of the press. Such tools may be classed as double action cutting and drawing dies for use in double action

presses; combination dies for operation in single action presses; triple action dies (which include a further operation of embossing or otherwise working the bottom of the drawn piece) which are used in triple action presses.

Redrawing dies of "push through" type are quite similar to the first operation or cupping tools, Fig. 7, except that they are adapted to receive the formed cup instead of the flat round blank, and to redraw the cup to the desired length and diameter by a series of operations in as many dies.

Double action dies are made both of the open or "push through" type and of solid bottom design. They each perform the combined operations of blanking and drawing in the one stroke.

GENERAL PRINCIPLES OF DOUBLE ACTION TOOLS

These two types of double acting dies are illustrated by Figs. 8 and 9 respectively. The double acting presses in which they are used are made with two slides, an outer slide which carries the combined cutting punch and blank holder *A* and which moves slightly in advance of the inner slide which carries the drawing punch *B*. The outer slide of the double action press is so controlled that after making its stroke downward it stops during about one-quarter of the revolution of the crank shaft.

The blank disk having been cut from the sheet by the edges of punch *A* and die *C* drops into the nest in the upper face of die *C* and is there held between the annular pressure surfaces *D* and *E* during the down dwell of the outer slide. While the blank is thus held under pressure that can be regulated to suit the requirements of any given case, the drawing punch *B* continues its downward movement under the action of the inner slide and draws the metal from between the pressure surfaces *D* and *E* into the shape desired. In this manner wrinkling is prevented.

For work which is straight-sided, cylindrical, or prismatic and which conforms to the shape of the punch without requiring a counterpart in the bottom of the lower die, tools of the push through type, Fig. 8, are used. They admit of pushing the finished work down through the die, the article being stripped from the punch at the beginning of its up-stroke by the stripping edge *F*.

Where a counter pressure in the lower die is necessary the closed bottom type of tool, Fig. 9, is used. These dies have in addition to the lower die, blank holder, and drawing punch, a push out plate or "knock-out" *G* which is arranged to rise at the same time as the blank holder *D* and thus lift the work from the die.

Examination of the view of the double acting press in Fig. 10 will show the method of controlling the dies just described. This design of press makes use of cams for actuating the outer slide *H* and the blank

cutter and holder, while the inner slide J with the drawing punch is crank operated. The cams are shaped to give any desired period of dwell

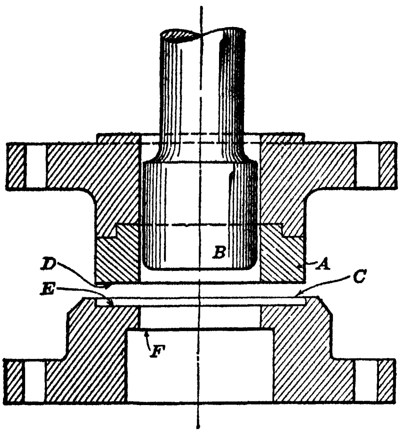


FIG 8 —Double action cutting and drawing die "Push through" type

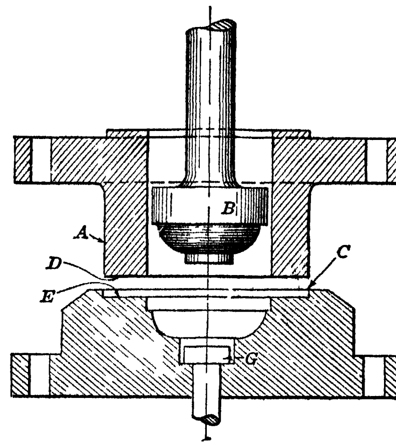


FIG 9 Double action cutting and drawing die Closed bottom" type

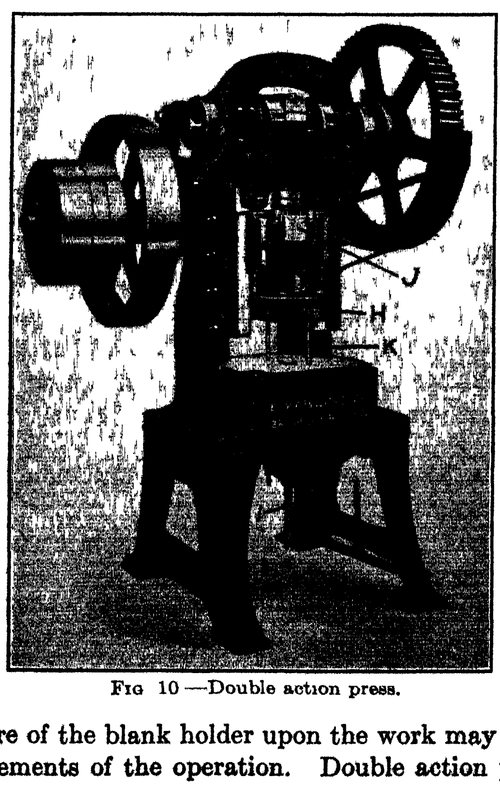


FIG 10 —Double action press.

and the pressure of the blank holder upon the work may be regulated to suit the requirements of the operation. Double action presses are also

made with two outer cranks for operating the outer slide with the blank holder. Also they are built with toggle action for the operation of the outer slide, these being used more especially for the larger and heavier drawing operations.

This view of the press also illustrates the arrangement of the knock-out apparatus K attached to the blank holder for lifting the work from the lower die where solid bottom dies, like Fig. 10, are employed.

The Double Action Cycle

At this point it may be well to introduce the drawing, Fig. 11, which shows a layout of the Waterbury-Farrel double-gate action. In the left-

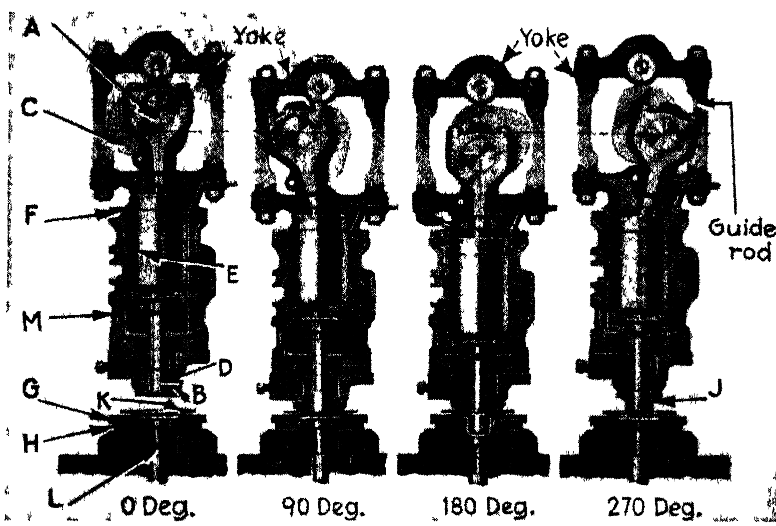


Fig 11 Double acting press gate.

hand view, the crank A is shown in its uppermost position. The blanking punch B is actuated by two cams C on the crankshaft, and the drawing punch D by the crank. The drawing punch is keyed into a holder carried by the plunger E, and the latter operates through the sleeve F of the blanking gate connection.

During the first 90-degree movement of the crank the blanking punch descends its full stroke, cuts the blank, forces it through the blanking die G, and holds it on top of the drawing die H. Simultaneously, the drawing punch descends halfway, preparatory to drawing the disk.

During the second 90-degree crank movement, the blanking punch holds the blank while the drawing punch completes its downward traverse and draws the shell.

During the third 90-degree crank movement both punches ascend together, the blanking punch completing its upward movement but the

drawing punch still having one-half of its upward movement remaining. Since the blanking punch remains stationary during the last 90-degree movement of the drawing punch, it acts as a stripper for the shell *J*.

It is usual to equip dies for blanking and drawing with a stripper *K* for the blanking punch. For work that is not drawn through the dies, a suitable knock-out *L* is employed, the position of which is shown in the illustrations. When the work is not ejected from the dies but is drawn through them, the action of the blanking gate *M* and drawing plunger *E* is the same as that described, but the relative position of the tools is different, since the drawing plunger must descend far enough into the dies so that the shell will be stripped from it by the underside of the drawing die. In this case no knock-out is used.

The Air Cushion

While much press work of the drawing nature is done on the single action press with spring and rubber pressure attachments, the increasing pressure with these as the punch descends may cause the blank to be held too tightly, or in avoiding this the blank may be too free at the outset of the stroke. This is particularly the case with drawing work of appreciable depth. A single acting press is shown in Fig. 12, drawing a half spherical shell for an instrument base. Here the Marquette pneumatic die cushion is applied under the press to provide firm and even pressure throughout the full extent of the stroke. While the example shown is a shallow draw, the same arrangement is applied to a variety of drawing jobs in this machine, some of them of much greater depth. This cushion makes it possible to use the single acting press for many jobs that naturally would be run on double acting presses and also enables the double acting press to be used for work ordinarily requiring triple acting presses. It provides even pressure to all parts of the blank to eliminate wrinkles, and if desired the pressure may be varied at different points in the stroke.

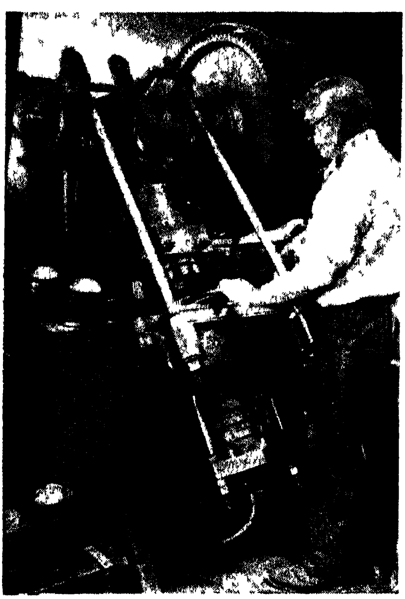


Fig. 12.—Use of pneumatic cushion below press.

Pressure on the draw ring is governed by the surface of the piston in the cylinder and the air pressure per square inch. Regulation of the

air pressure gives control of the actual pressure applied to the dies and work.

Triple Action Dies

Triple action dies operate the same as double action tools so far as concerns the blanking, blank holding, and drawing operations, but as the name indicates they add a third operation which may be the embossing, stamping, or special forming of the underside of the work, which is accomplished in the triple action press by a lower plunger under the bed which rises to meet the work as it is drawn through the main die. On the upstroke the work is stripped from the drawing punch by the stripping edge under the lower die and it can then be removed from the opening in the side of the raised bolster. A set of dies of this type with brief description is shown in connection with Fig. 32, Chapter I.

Combination Dies

Combination dies are used extensively for such work as cutting a blank, turning down its edge, and forming it into shape all at one operation. In appearance and method of operation such tools bear a close resemblance to compound dies. They are described at length in Chapter XII. Dies of this class are usually so arranged that the finished work is ejected from the die by the action of springs, and where an inclined press is used the finished article will slide back out of the machine by gravity.

Dies for Drawing Shells[1]

One of the most common uses for drawing dies is found in the manufacture of cases for rifle cartridges, and for the various sizes of shells for larger ammunition. These are of the general type illustrated by Fig. 7, which shows a first-operation set for forming up a shallow cup which is afterward extended to length by a number of drawing operations.

As a rule, these drawing operations are four or five in number and each reduces the diameter of the cartridge case by a definite percentage that varies with the type of case, caliber, and other factors. At the same time the length of the case is extended by each successive draw and the thickness of the walls is correspondingly reduced. In fact, the walls, which are naturally tapered toward the entire length, are very thin at the open end and are more or less ragged or irregular at the mouth; the surplus metal at that point is trimmed off in a separate machining process.

Another trimming operation consists in machining the head and form-

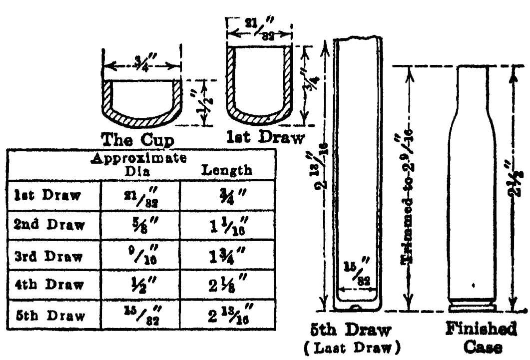
[1] Various sizes of cartridge cases made during the war were produced from steel owing to the shortage of copper and brass. A description of the operations is included at a later point in this chapter.

ing it for the extractor groove. The forming of the pocket for the primer is, in small caliber ammunition, performed under the punch press, though in larger sizes of cases this becomes a machining operation to be carried out in chucking machines or turret lathes where the head may be machined externally for size, grooved for the extractor, and drilled and reamed for the primer seat. Some reference to these operations is made later in the description of manufacture of the 37-mm. steel cartridge case which, though not of brass like the present cartridge case we are referring to, is handled through practically the same operations as brass cases of corresponding caliber.

It is of interest to note that the present so-called "solid head" cartridge-case head is a development of the old "folded" head, which was headed up with flange or rim and is still used in some forms of cases. The solid head became necessary when the rimless type was adopted in order to provide material for the extractor groove and at the same time to give the greater additional strength required in modern ammunition.

Smaller Work

In drawing smaller cases—as for .30-caliber rifle cartridges, a blank is used which is $\frac{1}{16}$ in. diameter by 0.808 in. thick. This is formed into



	Approximate Dia	Length
1st Draw	21/32"	3/4"
2nd Draw	5/8"	1 1/16"
3rd Draw	9/16"	1 3/4"
4th Draw	1/2"	2 1/8"
5th Draw	15/32"	2 13/16"

Fig. 13.—Drawing operation on .30-caliber cartridge cases.

a cup $\frac{3}{4}$ in. diameter by $\frac{1}{2}$ in. long and the first drawing operation produces a shell $\frac{21}{32}$ in. diameter by $\frac{3}{4}$ in. long. The sketch, Fig. 13, shows the successive stages of drawing. As with the larger cases, these shells are annealed before each of the drawing operations.

A design of blanking and cupping die, recommended by an authority for this class of work, is shown in Fig. 14. Here A is the die which is made with as large a cupping radius as possible to allow the shell to draw easily. The bottom of the die is relieved and the square edge a forms a good stripper which is positive in its action as the shell will expand enough after it has been drawn through the die to prevent it from going back up

through the die when the punch returns. This die is secured in a holder *B* by retaining ring *C*, which is threaded and screwed into the holder.

The part *D* is a stripper of the ordinary type for the blanking die and punch *E* which is secured in the drop forged holder *F*, a detail of which is shown to the right. The drawing punch *G* has a vent hole the same as the other punches illustrated, to prevent trouble with the shells sticking to the ends of the punch because of the vacuum held by the fit of the work to the punch surface It will be noticed that the top of the punch is slotted crosswise on opposite sides to receive the jaws of a holder *H* on the press slide. This provides a floating connection, as the holders may be clamped in position and the holes for *F* and *H* tapped in their respective punch holder plates. The floating drawing punch holder is shown in detail *H* at the right in Fig. 14.

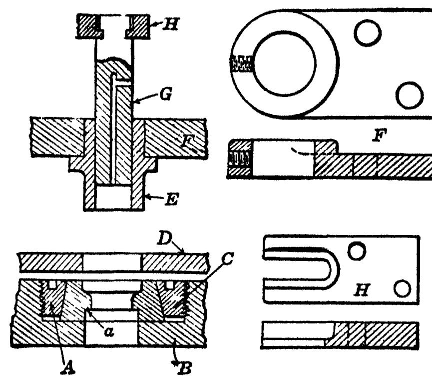


FIG. 14.—Blanking and cupping tools for rifle cartridge cases.

On work of this class it is customary to operate the blanking and cupping tools on the multiple principle with either two or four sets of dies in the double acting press.

Proper Vent in Punch Necessary

Reference may again be made here to the necessity of properly venting the drawing punch on work of this character. Besides the trouble likely

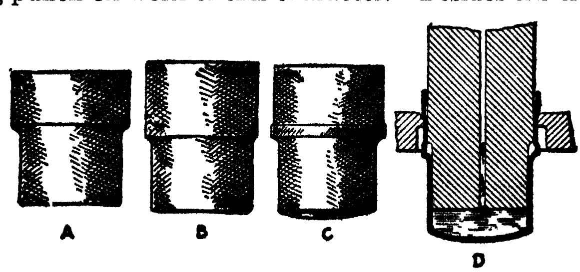


FIG. 15.—A freak shell and how it was made.

to be caused by the shell sticking to the punch when the air cannot escape, there is occasionally difficulty brought about by insufficient passage room for the lubricating liquid. An instance of this kind recently brought to attention in a shop handling various classes of shell drawing operations is illustrated by Fig. 15. This is an explanation of some of the so-called "freak" shells that are now and then produced:

In the engraving, views A and B show a certain kind of shell as it should be drawn and C represents a freak form discovered sometimes in putting through a lot of these shells. This was caused during the redrawing of the large diameter by an unusual amount of soap water used as a lubricant and occasionally left in the bottom of the shell. As the solution could not escape through the air hole in the ram when the punch descended, the result was that the solution ahead of the punch acted upon the shell in the manner indicated at D. This in turn caused the bulged part of the shell to be forced through the redrawing die without being operated on by the punch, which, in turn, caused this part of the shell to bulge after it was forced through the working part or edge of the die.

This trouble was remedied by drilling a larger air hole in the punch to allow the water to escape, and using care to keep the lubricant out of the shells as far as possible preparatory to feeding them to the die.

One Method of Cupping Thick Metal

Double acting presses and combination dies are not always available or practicable for certain work that comes along and when it is necessary to draw a shell from thick stock without such facilities a safe and efficient method is to blank the piece first and then cup it by means of tools similar to those shown in Fig. 16. Here the drawing die is shown at C, the punch at D, the bolster at E, and the stripper at F.

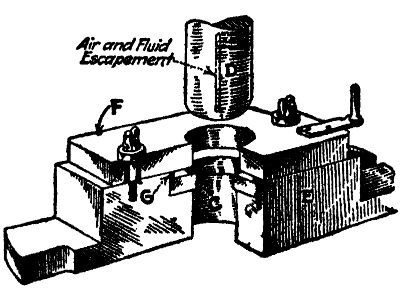


Fig. 16.—Clamp plate on die.

The blank is inserted into the nest G as provided, after which the stripper F is screwed down onto the blank to create pressure much the same as when a double acting press is used. This method has given perfectly satisfactory results, although, of course, it is necessarily slow as compared with the operation of similar work in the usual equipment.

A Comparison of Die Edges

Too much emphasis cannot be placed upon the importance of properly shaped die edges, and although reference has already been made to this point, it may be well to present here a comparison of proper and improper drawing edges.

Thus in Fig. 17 a sectional view of a cupping die is given, showing a liberal radius at A while an improper sharp corner is seen at B. As noted in preceding pages, such a corner would result in causing undue stress in

the material and if the tensile strength of the stock were exceeded the shell would be ruptured or fractured.

Referring to Fig. 18, all sharpness of the edges at the drawing point in a drawing die should be avoided and too abrupt angles or leads should not be permitted. Thus the slope of the angle in the mouth of drawing die *C* is shown with nicely rounded corner to allow the metal to draw or flow properly. However, after the die has been in service for some time it

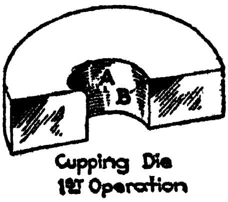


FIG. 17.

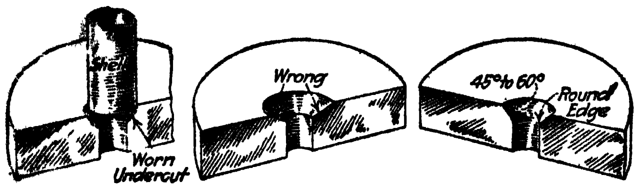


FIG. 18.—Shell-drawing dies.

may be noticed that the shell has become shorter, owing to the wearing down or undercutting of this edge as indicated at *D*, Fig. 16.

ANNEALING AND PICKLING OF BRASS SHELLS

In this section relating to the drawing of brass shells it may be well to include a few notes in reference to the annealing and pickling operations which are generally so essential between the successive draws for the production of satisfactory work and the preservation of the drawing tools.

While annealing is sometimes eliminated preparatory to a reduction, it is not advisable usually, for the material then becomes too hard and brittle, particularly when thin stock is drawn. The work is then severe upon the dies and in cases, like the redrawing of shells, say, $\frac{5}{16}$ diameter by 4 in. long, of 0.010-in. stock, it has been noticed that the product is inclined to be crooked or bent when not previously annealed. Another condition that will result in bent shells is having the back of the die broken out; this naturally does not occur when the diameter of the shell is large or it is drawn from thick stock.

Pitting of the die, scratched work, and shell breakage are largely attributed to lack of sufficient precaution in this direction. Too little annealing is as detrimental as its extreme, and should the annealing be insufficient (1000 to 1100° F. is usually about correct), the bottom of the shell is likely to punch out; the die will pit very easily. On the other hand, work that has been subjected to too high a temperature has decreased ductility and tensile strength. Under this latter condition a shell may or may not draw to its full length, although should no breakage occur, the smooth finish that is most desirable is lacking, and in its place appears an uneven, scaly product.

Care Necessary in Annealing

Extreme care should be used in annealing. If a pyrometer is not available, adjust the furnace until it shows a bright red glow, allowing the work to remain therein a sufficient length of time to bring all pieces to a like color, say, a cherry red.

If the temperature of the furnace is not increased, the work will not become overheated, even though the shells are allowed to remain in it longer than the predetermined time. Use sheet iron pans with covers, to prevent oxidation of the work and lessen the labor of pickling, but see that the shells are free from soap or oil and that they are washed thoroughly before the annealing operation. After the annealing the work is pickled in order to remove all evidence of scale or oxidation, and it should be remembered that the same degree of caution is required as for the annealing process.

The Pickle Bath

For the pickle, ten parts of water to one of sulphuric acid gives a satisfactory mixture for warm pickle; but if cold, seven parts of water to one of sulphuric acid is a good combination. This, however, may be mixed to suit conditions. In preparing the bath always put the water in first, the acid last, the chemical action making this precaution necessary.

After all oxidation is removed, the shells should be immersed and washed thoroughly in hot or boiling water. Lukewarm water will not suffice. The equipment for this should consist of a wooden tank with provision for an outlet and an inlet for a continuous supply of clear water. Should this operation be improperly performed and the work be exposed to the air, it will be noticed that reddish spots appear upon the surface of the shells, and in some instances a green sediment or verdigris, which is nothing but the acid, a condition to be particularly avoided. The shells on top may not appear to be as mentioned, but investigation of the work halfway down or at the bottom will surely result in this finding.

Effect of the Acid on the Tools

It is needless to state that the acid has quite an affinity for steel; and should the work in the condition mentioned be redrawn, not much progress will be made as the tools will become pitted almost immediately and eventually ruined.

Suppose acid spots have not made their appearance; this does not necessarily mean that the work is clean. Shells are improperly cleaned so long as there is a vestige of scale or oxidation upon them, and it is then time to strengthen the mixture or to investigate the methods of the workman, who perhaps has passed the shells in too great a hurry.

The redrawing of shells that have any oxidation upon them is simply impracticable and profitless. Aside from the wear caused on the tools, difficulty will be encountered in the plating or finishing department with the bright dipping or plating as the case may be, all because the scale has been ironed into the surface of the shell by the drawing process.

A good way to prevent the oxygen from acting upon the shells is to immerse them in a receptacle of some kind filled with water or a soap mixture. Attached to it should be a pipe for heating. If there is any acid on the shells it will soon rise to the surface in a curdled state, where it is very readily skimmed off.

Redrawing tools should always be kept in a perfectly smooth, brightly polished condition so far as possible to assure satisfactory operation; but if conditions exist such as noted above even this care of the punches and dies will be of little avail.

Experience with Steel Shells

There is some difference of opinion in respect to the relative difficulties of drawing brass and steel shells, particularly in reference to the annealing

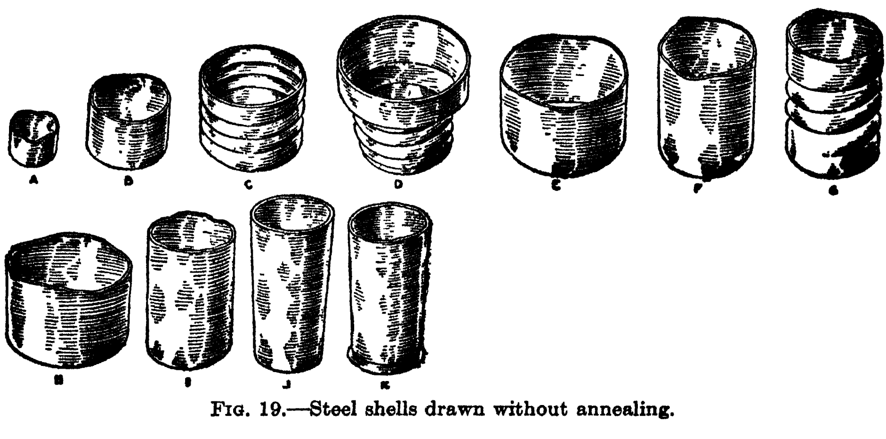


Fig. 19.—Steel shells drawn without annealing.

operations required. It has been the observation of some that in cupping and deep drawing of sheet metal, steel can be drawn deeper than brass without annealing although the first draw on a brass shell can be made slightly deeper than steel. It is necessary to run the press a little slower for steel than for brass.

In Fig. 19, at *A* and *B*, are shown some steel shells which were made in one operation. Those at *C* and *D* require two draws although at times material has been available from which these could be drawn in one operation. The largest of these shells have always been made in two draws, and the same shop is now using two draws on all shells that have a length equal to the diameter. After trimming, the large shells are threaded but

there is no annealing between operations. It is believed that if the shells were of brass it would be necessary to anneal them after the first operation. At *E*, *F*, and *G* are shown the three operations necessary to make the piece from 0.018-in. cold rolled steel. There are two draws followed by rolling of the thread but no annealing is done between operations.

From *H* to *K* are shown the successive steps in making a screw driver ferrule of 0.030-in. cold rolled steel. This is also made without annealing, but if it were of brass it would be necessary to anneal it at least once.

DRAWING STEEL CARTRIDGE CASES FOR 37-MM. SHELLS

One of the earliest classes of work ever handled in the drawing press, in fact one of the types of work which led to the remarkable development of that piece of production equipment, was the drawing of cartridge cases (or cartridge "shells" as they were formerly called). These were at the time of small caliber and in most instances were made of brass, though in some small sizes, such as .22 and .32 caliber, cases were also made of copper. These were for the rim-fire class of cartridge. Scarcity of copper and hence of cartridge-case brass during recent years of the Second World War led to the development of steel cartridge cases for this 37-mm. size and for certain other sizes.

The shift from brass drawing operations to the use of steel for this purpose created many difficult problems which had to be solved hurriedly, and along with this pressure for haste were the added difficulties involved in producing an article running up into millions of units, with extreme requirements in regard to dimensional accuracy and dependability in service. It will be of interest in this chapter to note some of the principle steps in handling the manufacture of the 37-mm. cartridge cases.

The Armament Section of the *American Machinist* in one of its issues during the Second World War[1] carried a detailed account of this undertaking as described by C. L. Patterson, general manager, Corcoran-Brown Lamp Division, The Electric Auto-Lite Company, and Lt. Col. Harold R. Turner, the Cartridge Case Industry Committee, U. S. War Department. We have reproduced here the Operations Schedule and illustrations of the cartridge case from blank disk to finished product, together with liberal descriptive matter from the body of the text. It is believed that manufacturers of deep-drawn steel products, whether cartridge cases or other articles, will find much information of great value in studying the original report referred to above. As users of this treatise on *Punches and Dies* are naturally interested to a degree in details of press-tool construction it has seemed advisable to include also views of typical dies employed for the work.

[1] *American Machinist*, July 22, 1943.

The Form of the Coined Cup

It will be noticed that the cup, Fig. 20, is of unusual type, resembling a hollow cone rather than the conventional cartridge-case cup with its cylindrical body and rounded closed end. Many tests by the above company and other manufacturers, with steel samples of various analyses and

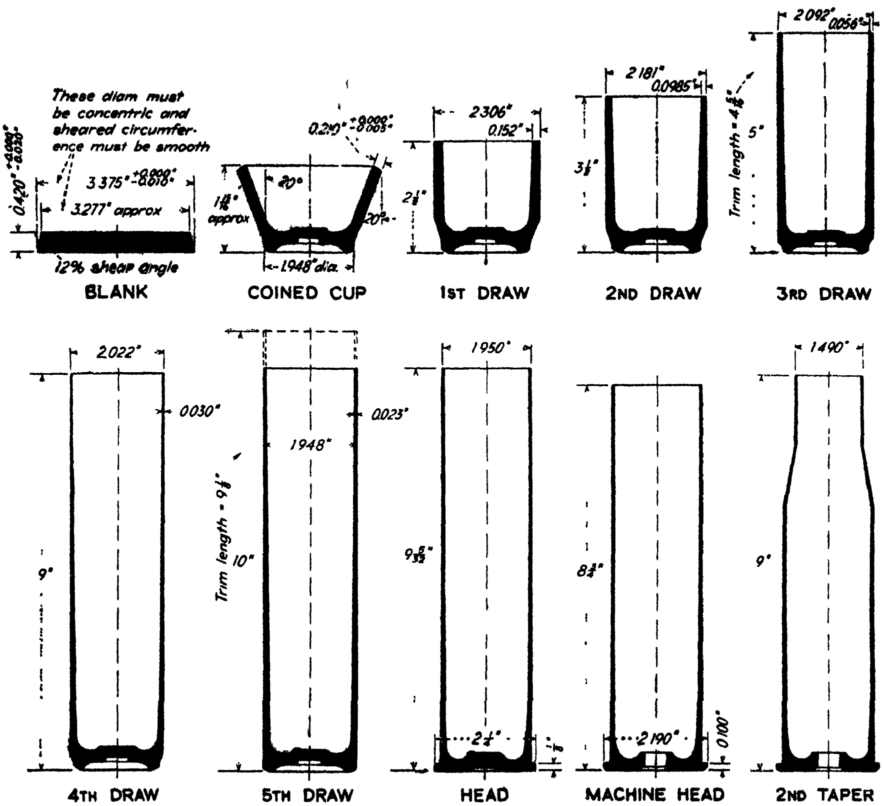


FIG. 20.—Five draw operations to cold-form a 37-mm. steel cartridge case of the type shown. Mild steel blanks are used.

metallurgical conditions, have shown that cold drawn steel cartridge cases can best be made from a 0.20 to a 0.30 carbon steel of carefully selected analysis and of small grain size. The material should be 100 per cent spherodized and the blanks should have a hardness of 55 to 65 Rockwell R. Experiments helped establish a way to avoid eccentricity of the case walls due to blank slippage when contacted by the cupping punch. After the cylindrical cup has been formed from the coined cup in the first draw, punches and dies should be proportioned to apply drawing pressure only along the cylindrical wall. Little or no metal should be

pulled over from the base section in succeeding draws. The cup in each draw must fit closely around the contour of the punch; clearance between cup and punch must be the minimum that will allow entrance of the punch to the bottom of the case. In connection with all the experiments carried out to find proper steel selection and to work out a proper drawing procedure, the authors of this report express full appreciation of the invaluable advice and cooperation of Ordnance Department officers, particularly Lt. Col. L. S. Fletcher, who was then at Frankford Arsenal, and other Arsenal officials. The Cartridge Case Industry Committee also has been particularly helpful in this work.

Among many details to be determined were proper sizes and shapes for punches and dies. It is pointed out that the company first used die rings made of tool steel, nitrated to provide the required surface hardness, after which cemented carbide die rings were substituted. It is stated that the cup wall must be concentric within 0.008 in. for successful use in the draw dies.

Operation Schedule

The complete list of operations in their order is covered in the accompanying Operations Schedule. As outlined, the first operation is cleaning the coined cups by passing them through a conveyer type of washing machine in which the alkali solution is kept at about 160° F. Then they are bright annealed in a G. E. furnace through which they are carried in wire baskets, with only a layer in a basket and scattered for uniformity of heating. The cups remain in the heating zone of the atmosphere furnace for 22 min. at a temperature that is automatically held at 1650° F. Power rollers then move the baskets into the cooling chamber of the furnace for slow cooling to about 180° F. in about 60 to 65 min. The baskets are then run out onto a roller table at the discharge end and the cups are dumped into a waiting truck.

The same annealing equipment and heating cycle are employed for the anneals that follow the first, second, and third drawing operations. The cases are not annealed after the fourth and fifth draws, as will be explained later. They are held between 62 and 65 Rockwell B.

In the third operation, the cups are loaded into wire baskets for dipping into a tank of a neutral soap-base coating which is kept at 210° F. and in which the baskets handled by pneumatic hoists are suspended for 3 min. This coating is a lubricant for the first draw operation, and it has been found satisfactory in place of the copper plating formerly done before each draw, and thus saves the copper for other uses. The coating is easily stripped off the cups with cold water and it is essential that they be kept away from water until the draw operation is completed.

ACTUAL DRAWING OPERATIONS

In the first drawing operation—performed in an HPM 150-ton hydraulic press—the cup, approximately $1\frac{5}{16}$ in. diameter at the base and $1\frac{5}{16}$ in. long, is elongated to about $2\frac{1}{2}$ in. Two punch and die sets are used, with an operator at each side of the press so that two cups are drawn at each cycle. Controls are interlocked so that each operator must have both hands on control push buttons before the press ram will descend. Actual pressure on the ram during the draw is about 120 tons. This is also the average pressure for the other drawing operations. A typical drawing die set is shown in Fig. 21.

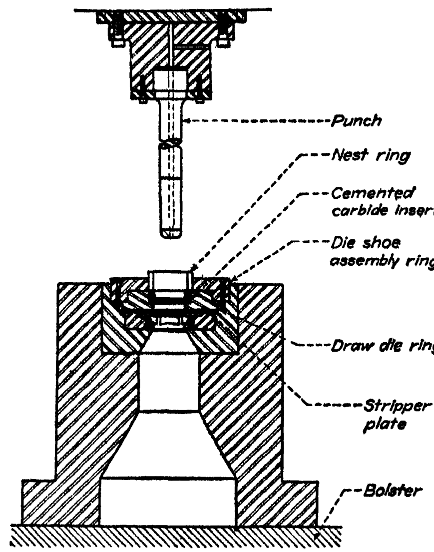


FIG. 21.—A draw die set.

The sections through the case lengths in Fig. 20 show the actual effect of each draw and also of the trimming operations. The figures show the increase in length, the reduction in diameter, and the wall thickness. The operation schedule covers the series fully including inspection. Press speeds are as follows:

First and second draws, 300 cycles per hour
Third draw, 250 to 275, cycles per hour
Fourth draw, 225 to 250, cycles per hour

The carbide die mentioned is shown in one size in Fig. 22. It has been found that the 20-degree entrance angle of the carbide insert and the $\frac{1}{4}$-in. radius between the angle and the cylindrical throat of the insert must be held closely for successful drawing of these steel cases. This applies to all the draw dies in the series.

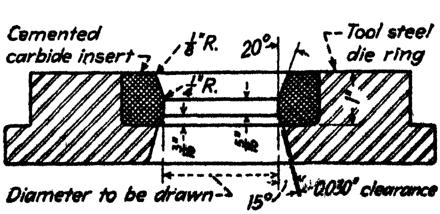


FIG. 22.—Draw die ring.

It is also necessary to flood a non-saponifiable lard-base coolant into dies and work, and this coolant must be kept free from water as only a small percentage of water in the coolant will strip off all the lubricating coating previously applied.

The third draw is followed by the first trimming operation, No. 13 on the schedule; this is performed on an automatic machine which trims the case to $4\frac{5}{16}$ in. Then follow washing, annealing, and coating as before.

In the fourth draw operation, speed is reduced to about 225 to 250 cycles per hour. Little trouble is experienced in the first three draw operations in stripping the cases off the punches. However, in the fourth and fifth drawing operations stripping with the regular fingers in the bottom of each die set is not always successful. To reduce stripping difficulties in these operations, a hydraulic stripping arrangement is being tried out. The cooling liquid used on the press is pumped through the regular venthole in the punch. Hydraulic pressure between the end of the punch and the bottom of the case cavity "cracks" the case off the punch about 1 to $1\frac{1}{2}$ in. This loosens the case sufficiently to permit the stripper fingers to remove the case in the usual manner.

While the fourth draw is followed by washing and coating, annealing is eliminated to permit cold drawing of the metal to build up physical properties in the wall of the case. As the fifth—and final—drawing operation is the most severe of all, a second coating of the soap-base lubricant is applied over the first. Practically half the total reduction is accomplished in this final draw, but the same tonnage (150 tons) is exerted by the ram of the press.

Permissible Die Wear

Among other established points in this article is the fixed limit for wear of dies. Thus maximum wear of 0.003 in. is permitted in the throat of the carbide insert for the fifth draw die. When wear and repolishing operations increase the diameter above this allowance, the insert is polished out to the diameter required for the fourth draw die. When worn more than 0.003 in., this insert in the fourth die is repolished for the third draw. This is repeated until the insert is worn too large for use in the first draw die.

When the draw punches wear to a point where they are too small for use, they are salvaged by polishing and applying a hard chrome plate, which sometimes may be as much as 0.002 or 0.003 in. thick, with satisfactory results. Frequent polishing is necessary in the die rings and on the punches for the fourth and fifth draws, since the very high draw pressures cause trouble with scratched work if the tools are not properly maintained.

Trimming and Other Work

After the fifth draw, the cases are trimmed to a length of about $9\frac{1}{8}$ in. and are then washed and ready for heading in 600-ton presses where six dies are set up around a ratched-operated dial on the bolster of the press

and the machine is kept in continuous operation. A heading die is shown in Fig. 23. The heads and primer holes are then machined in six-spindle chucking machines, using high-speed steel and carbide-tipped tools. Here a shop inspector checks the cases 100 per cent for size and concentricity of head and primer hole surfaces.

Following Operation No. 24 just mentioned, the cases are again washed with hot alkali solution and then run through the conveyer type of flame annealers for annealing their open ends before tapering. As the cases pass the burners, they rotate slowly and are evenly heated during

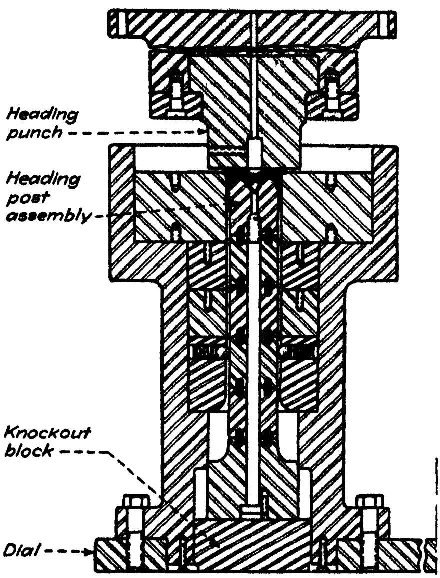


FIG. 23.—Heading die set.

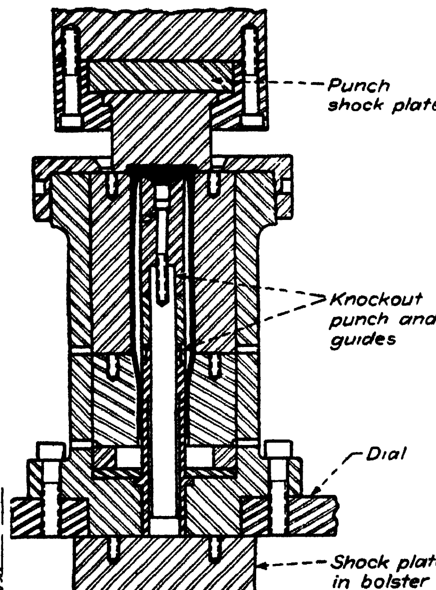


FIG. 24.—Tapering and sizing dies.

the 67 sec. taken to carry them through the machine. Then the cases are pickled by dipping for about 5 min. in a 10 per cent sulphuric acid bath, and then are transferred to a cold-water rinse and a neutralizer bath maintained at 180° F. The mild neutralizer leaves a film on the surface of the case to aid in preventing corrosion.

Two tapering operations are used to form and size the mouth of the case. Clearing 60-ton mechanical presses are employed for this work, with six die sets mounted on the dial plate of each machine. A tapering and sizing die set is illustrated in Fig. 24. Inspectors at these presses check the cases for buckled mouths and other possible defects; at the sizing press, gages are used to ensure that the cases are properly finished.

After sizing, the cases are trimmed in automatic machines to final length, and then the mouth ends are burred as per schedule (see Oper-

ation No. 31). Then the cases are again washed in alkali solution and the mouth ends annealed in flame annealers like the equipment used for taper annealing. This is to permit crimping the mouth of the case around the base end of the projectile and to give proper obturation in firing.

The cases are now stress relieved by being suspended on wire hooks and are passed through a large surface combustion conveyer type of furnace. Since they are held here for about 20 min. at 725° F. they are in the heat zone about 50 min. during the furnace cycle. The cases are then cleaned by pickling, using the same equipment mentioned above, then washed, and then dipped in a 50 to 1 soluble oil solution to provide a film to protect against rusting while the cases are passed through the final inspection room for inspection by the company and ordnance inspectors. The remaining operations from here on to packing of the product are indicated in the schedule. These operations are of course performed in the shop after the cases are returned from final inspection, and include cleaning by dipping in a solvent that removes the oil film, machine-stenciling identifying data on the side of the cases, varnishing with special phenolic varnish and de-tear, and baking varnish on case in oven with flight conveyer. This baking is done at 450° F. for 45 min. to harden the 0.0005-in. thick varnish coat.

Corcoran-Brown Operations on a 37-mm. Steel Cartridge Case

Operation No.	Operation Performed and Equipment Used
x	Blank, cup, and coin—done by separate contractor.
1	Wash cup with hot alkali solution—Blakeslee belt type of metal-washing machine.
2	Anneal cup—No. 2 G.E. electric annealing furnace with reducing atmosphere for bright annealing.
3	Coat with No. 1033 Gilron neutral soap-base coating—dip tank, wire baskets, and pneumatic hoist.
4	First draw—150-ton HPM hydraulic press with two punch and die sets and two operators.
5	Wash case with hot alkali solution—same equipment as for operation No. 1. Cases placed on conveyer with open end down to drain readily.
6	Anneal case—same equipment as for operation No. 2.
7	Coat case—same equipment and solution as for operation No. 3.
8	Second draw—150-ton HPM hydraulic press with two punch and die sets and two operators.
9	Wash case—same equipment as for operation No. 1.
10	Anneal case—same equipment as for operation No. 2.
11	Coat case—same equipment and solution as for operation No. 3.
12	Third draw—150-ton HPM hydraulic press with two punch and die sets and two operators.
13	Trim mouth end of case—V & O automatic cartridge case trimmer.
14	Wash case—same equipment as for operation No. 1.

Operation No.	Operation Performed and Equipment Used
15	Anneal case—same equipment as for operation No. 2.
16	Coat case—same equipment and solution as for operation No. 3.
17	Fourth draw—150-ton HPM hydraulic press with two punch and die sets and two operators.
18	Wash case—same equipment as for operation No. 1.
19	Coat case—same equipment and solution as for operation No. 3.
20	Fifth draw—150-ton HPM Fastraverse hydraulic press with two punch and die sets and two operators.
21	Trim mouth end of case—V & O automatic cartridge-case trimmer.
22	Wash case—same equipment as for operation No. 1.
23	Head case—800-ton Clearing mechanical press with six die sets on dial table.
24	Machine head and primer hole—New Britain-Gridley six-spindle automatic chucking machine.
25	Wash case with hot alkali solution—Blakeslee basket of type metal washing machine.
26	Taper anneal—Morrison conveyer type of flame annealer.
27	Pickle in 10 per cent sulphuric acid solution, rinse, neutralize in mild alkali solution—dip tanks and wire baskets.
28	First taper—60-ton Clearing mechanical press with six die sets on dial table.
29	Size (second taper)—60-ton Clearing mechanical press with six die sets on dial table.
30	Trim mouth end of case—V & O automatic cartridge-case trimmer.
31	Burr mouth end of case—Delta bench type of drill press with special three-bit cutter and work-holding fixtures.
32	Wash case—same equipment as for operation No. 25.
33	Mouth anneal—Morrison conveyer type of flame annealer similar to that used for operation No. 26.
34	Stress anneal case—surface combustion furnace with flight conveyer.
35	Pickle, rinse, and neutralize—same equipment as for operation No. 27.
36	Wash case and dip in soluble-oil solution—Blakeslee basket type of metal-washing machine and oil tank with dip baskets.
37	Final inspection of finished cases—inspection bench with canvas belt conveyer down center.
38	Clean cases—dip in solvent to remove oil film.
39	Stencil identifying data on side of case with marking ink—Markem automatic stenciling machine.
40	Varnish and de-tear—special Ransburg unit with overhead chain conveyer, portable dip tank and charged screens.
41	Bake varnish on case—Morrison oven with flight conveyer.
42	Pack cases in cartons for shipment.

Final Inspection Operations on 37-mm. Case

Operation No.	Operation Description
1	Visual inspection for folds, cracks, and other defects.
2	Check over-all length with go and not-go gage.
3	Check depth of counterbore in base end with go and not-go gage.

Operation No.	Operation Description
4	Check thickness of base with dial indicator comparator gage.
5	Check inside diameter at mouth end with go and not-go gage.
6	Check primer hole for size with taper plug gage.
7	Check flange thickness with go and not-go gage.
8	Check groove and flange diameters with go and not-go gage.
9	Check counterbore diameter with go and not-go gage.
10	Check height to shoulder (distance from base to datum diameter) with go and not-go gage.
11	Place case in special gage to check maximum profile.
12	Place case in special dial indicator gage to check the concentricity of the primer hole with the outside diameter.
13	Check wall thickness with special dial indicator gage.

NOTE: Operations 1 to 12, inclusive, are preformed on all cartridge cases by shop inspectors. Operation 13 is necessary on only about 10 per cent of the cases passed by the preceding operations.

TWO METHODS OF DRAWING A DEEP FLANGED STEEL SHELL

Individuality of experience and method is nowhere more pronounced than among expert mechanics responsible for the production and opera-

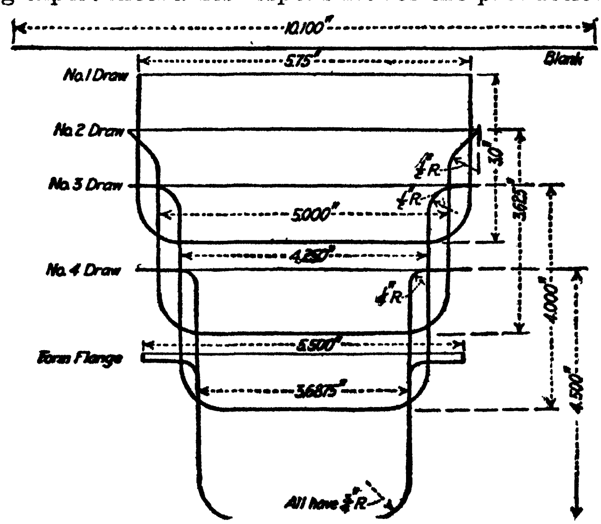


FIG. 25.—Drawing a flanged shell.

tion of press tools. There are usually several ways to solve a given problem in die construction, and the character of the tool layout for a difficult piece of work will differ in accordance with the experience of the men who have the matter in hand.

One method of attacking the problem represented by Fig. 25 is as follows: The flanged shell here shown is made in seven operations, one blanking, four drawing, one trimming, and a final forming operation to turn up the edge on the flange. The material is 0.035-in. drawing steel

and the shell is finished without any annealing. The blanks are made on a rotary shearing machine. They are then run through an ordinary "push through" type of drawing die, making a straight shell 5.75 in. diameter, 3 in. long.

For the second operation the same type of die is used but it has an inside blank holder to prevent the stock from wrinkling; and instead of pushing the shell through, it is drawn just far enough to leave a flange the size of the radius on the drawing edge of the die. This is the starting of the flange. The trimming operation follows in order to make the flange round. This was found necessary in order to obtain the required uniformity of pressure in the next drawing operation. The trimming is done with press tools, the punch being the lower member and the die the upper. The piece is located centrally on the punch by means of a pilot the size of the inside diameter of the shell.

The third drawing operation reduces the shell from 5 in. to 4.250 in. in diameter. The die is of the same form except that it has a cast iron stripper plate to the underside of which is fastened a tool steel ring that acts as a pressure plate. When the descending punch comes in contact with the stripper, it flattens out the flange on the face of the die as the punch completes the down-stroke. The radius joining the flange and the body of the shell is now finish size. It required some experimenting to determine the correct time for the pressure plate to come into contact with the flange as the shell was being drawn, in order to exert enough pressure on the flange to keep it from wrinkling, yet not enough to cause it to roll over.

The Fourth Draw

The fourth drawing operation reduces the shell from 4.250 to 3.6875 in. in diameter. In this draw it seems to require sufficient pressure to cause the flange to roll in order to prevent it from developing wrinkles. Then as the flange is flattened at the bottom of the stroke there is a circular crease on the flange due to the action of the metal in being bent beyond a horizontal plane and straightened out again.

Owing to the flange not being strong enough to stand the stress of stripping, it has been found impracticable under existing circumstances to turn up the edge on the flange in the finish operation. It is therefore necessary to make a separate operation of this, the final one in the development of the piece.

Referring to Fig. 26, *A* is a cast iron punch holder bolted to the ram of a toggle press with 13 in. stroke; *B* is a jacking ring and *C* the punch. At *D* is the stripper plate and *E* is a tool steel pressure plate, the radius on which is made to conform to that on the dies so as to iron out the metal on the flange. A positive knock-out *T* is operated by side rods screwed

into the ram of the press. At G is the die and at H the die shoe, which is bolted to the bed of the press. The duty of the two springs U is to keep the stripper D up on the punch and out of the way of the operator. The two rods S on the side serve as guide rods. They also hold the stripper plate D in place as the punch ascends, thus pulling the shell from the punch.

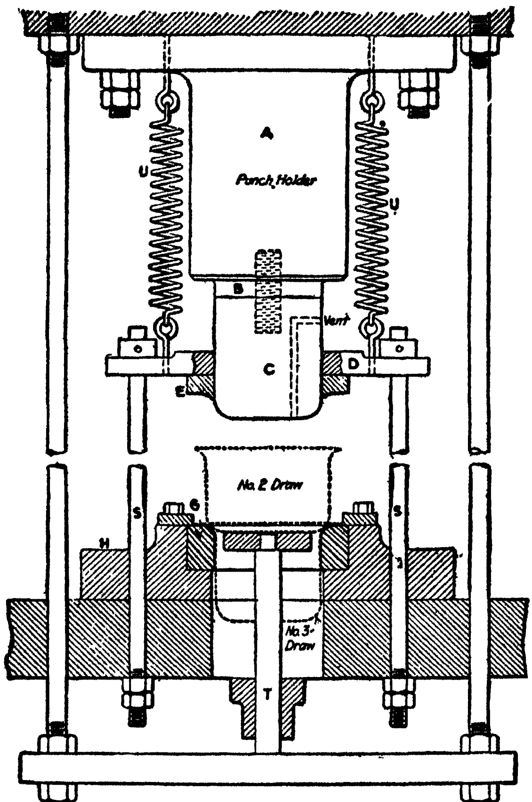


FIG. 26.—Arrangement of the dies for drawing shells shown in Fig. 25.

By trying out various diameters for the punches, it was found that best results were obtained when the diameter of the punch was from 0.010 to 0.012 in. smaller than the size determined by subtracting the double thickness of the stock from the inside diameter of the die. The lubricant used was a compound to which was added about 20 per cent of lard oil and a small quantity of sulphur.

An Alternative Method

Another method which has been suggested for handling this shell drawing undertaking is as follows; it being believed that the shell could be

blanked and drawn in three, possibly two operations. This method refers to dies for a double acting press, and Fig. 27 shows the type of die used for blanking and cupping. The blanking punch acts as a flange holder for holding the stock when drawing. The head on the drawing pad or die irons out all wrinkles that tend to form in the stock. The cup does not have to be drawn entirely through the die, but can be left with a flange and can be about the size of the second draw in Fig. 25.

The blanking die must have shear ground on it, and the pressure exerted by the flange holder must be regulated to keep out all wrinkles and not thin the stock down too much. The head must have a large radius, so that the stock will not be broken and pulled in. About $\frac{3}{4}$ or $\frac{7}{8}$ in. is recommended for the size cup here shown. The drawing punch must be regulated to draw the right depth. These points can be determined by trial.

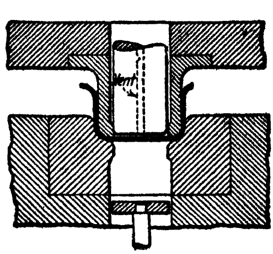


FIG. 27.

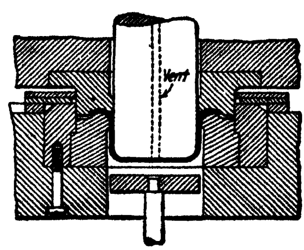


FIG. 28.

FIGS. 27–28.—Drawing steel shells.

The type of die used for the drawing operations is shown by Fig. 28. This is also a double acting die. The die block is belled out to take the cup from the preceding die and has a large radius on the edge of the drawing portion of the die. A flange holder comes down inside the shell and holds the stock so no wrinkles can form, while the ram draws the cup as before to the proper depth.

After the shell has been reduced to the proper diameter, the flange should be flattened out on a single acting press and then trimmed. All dies should have guide studs or posts to aid in setting up and keeping them in line. If one stud is made larger than the other, the die and punch will not turn in relation to each other but will go together the same way each time.

THE "PINCH OFF" TYPE OF PUNCH AND DIE

The principle of the draw and "pinch off" punch and die is used extensively in making jewelry settings and similar parts but is little known outside of factories specializing on this line of operations. The following description relates to a punch and die of this kind for making the box

cover shown in Fig. 29. The stock is 0.014-in. low brass, dead soft, and the press is a single action machine run at 150 revolutions per minute.

The tools are shown in Fig. 30. The one feature to be emphasized is the fact that with these tools properly made, and regardless of a slight variation in the thickness of the stock, the cups or shells will always be of uniform height if the trimming punch is kept sharp. In the engraving, *A* is the die; *B* is the stripper which is held in place by cap screws *C*. It will be noticed that the drawing edge *D* of the die is well rounded. The exact amount for this work can be determined only by trial, although a man accustomed to these dies can almost always get the radius right at the first attempt. There is one important thing about this radius, that is it should not run into the straight part of the die *A* at a tangent but should run out as shown in the section at *K*, leaving an abrupt shoulder, as at *L*. This assists the pinch off punch to trim the cup evenly. In making dies for shallow settings it is only necessary to break the edge with an oil stone. Another important point is that the die should be ground absolutely parallel without any clearance and the stripping edge *E* of the die must be sharp in order to strip the cup from the drawing punch *F*.

The pinch off punch *G* is left large for grinding, and is drilled and tapped for a standard thread. The end of the punch is bored as shown. This is to permit regrinding on the face to sharpen and also to act as a means of keeping the drawing punch *F* concentric with the blanking punch. This latter feature is not usual in the practice of jewelry toolmakers, who generally make the punch in one piece. In this case it is necessary when resharpening, to anneal the punch, true it up carefully in the lathe, turn back the pinch off shoulder as well as the draw punch to correct height and shape, and reharden, with the possibility of the punch going out of round. Still, this method is practical when the setting is too small to permit of the use of the loose draw punch or where so few pieces are wanted that it would not pay to go to the expense of making the improved type of punch.

It will be found necessary to shear the stock somewhat wider than in general practice for plain blanking, and this amount can be determined only by trial. The stripper should be milled with little more than enough room for the stock to pass. This will hold the stock flat and prevent wrinkling, to some extent. With the feed rolls tight and the dies made right, this will be found a very cheap and satisfactory way of making shallow shells.

Other Applications of the Pinch-off Principle

This principle of draw and pinch off tools can be applied advantageously to other work. Consider for the moment Fig. 31, which is the powder box for which the cover, Fig. 29, is made. This box is finished

$\frac{1}{32}$ in. deep and crowned on the bottom the same as the cover. On a double acting cam-actuated press, the box is first drawn about $\frac{1}{32}$ in. larger in diameter than finish size. Then it is redrawn and pinched off to the proper height. A very satisfactory result is obtained and no further trimming is necessary if the punch is kept sharp.

This type of punch and die can very often be used to advantage in drawing and trimming steel shells for various purposes. In Fig. 32 is

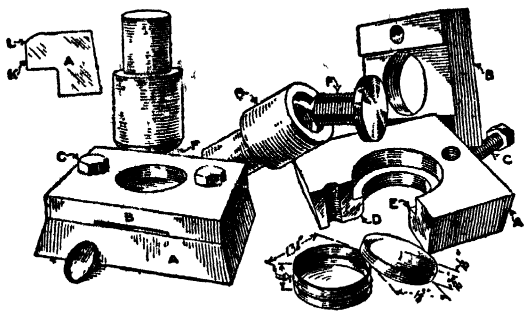


FIG. 30. FIG. 31. FIG. 29.
FIGS. 29–31.—Application of "pinch off" dies.

shown a cup made of 0.0437 sheet steel, drawn upon a cam-actuated cut-and-draw press and then redrawn to the dimensions given. After annealing it had been the practice to turn or face off in a drilling machine, the cup being held in special jaws while the cutting tool was fastened in the spindle. The cup was then put through a final draw and again sent to the drilling machine to be faced off to correct height, as shown at

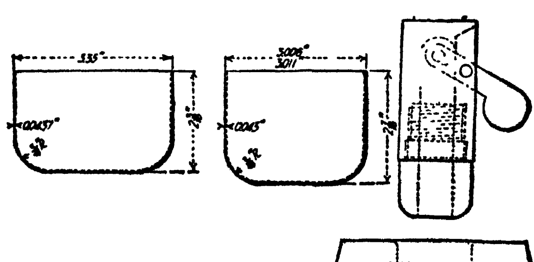


FIG. 32. FIG. 33. FIG. 34.
FIGS. 32–34.—Application of "knock off."

Fig. 33. As may be supposed, there were many rejections due to the facing off of too much material or to rough edges. In the latter case it was necessary to send the pieces to the polishing room to be ground, all of which tended to increase the cost of production.

To avoid further trouble of this character, a punch was made like the one in Fig. 29. The results were very satisfactory so far as the finished cups were concerned. While the draw punch was new and smooth, the

work stripped off without any trouble but as soon as the punch became roughened a little the shells began to stick. So a special stripper or knock off was applied as in Fig. 34.

This consists of a central plunger which is connected to the arm seen projecting from the side of the punch. The end of this arm strikes the top of the die as the punch descends just after the trimmed cup has passed through the drawing die and is free to be stripped off the punch. As the punch is permitted to continue on through the die for a short distance the cup is started or forced off for about 1 in. and as the punch is withdrawn, is stripped clear off by the shear edge of the draw die.

This device operates with entire satisfaction and is the means of saving two facing operations in the drill press with the usual losses.

Drawing Dies for Lock Parts

Among other press tools built at the Schlage Lock Company's plant are a number of drawing dies for production of lock parts, such as sheet

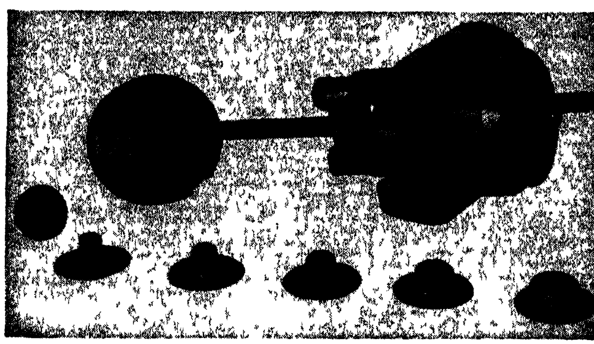


Fig. 35.—Inverted drawing dies for knob shank.

metal knob shanks, latch housings, etc. A knob shank drawing die of inverted type is shown in Figs. 35 and 36. This die is one of a series used in producing this metal part from the round blank. Five dies of this kind are used in drawing the blank from a diameter of $2\frac{7}{8}$ in. to the final flanged shell which is $\frac{45}{64}$ in. in diameter by $\frac{31}{32}$ in. long with a flange diameter of $\frac{3}{8}$ inches. The reduction in flange size from the original diameter of $2\frac{7}{8}$ in. is made in the cupping operation (the first draw), after which the flange is not affected in size by the drawing processes. The metal used is deep drawing soft brass, 0.032 in. thick, or No. 20 gage.

The sketches in Fig. 37 show the reductions in the different drawing operations, with sizes closely in proportion. Following the drawing, the piece is placed in a flattening die, and the flange is then pierced, trimmed, and formed. A shaving operation produces a series of finely spaced corrugations by which the two halves of the knob shank are locked together as shown at the left of the row of blanks in Fig. 35. For some work of

this kind a progressive die is used which combines all of the drawing operations and carries the blank along in the strip by two narrow connections between the flange and the scrap until the final draw when the work is knocked out free of the strip. The principle of the drawing dies is the same, however, as in the single-operation tools covered in the present description.

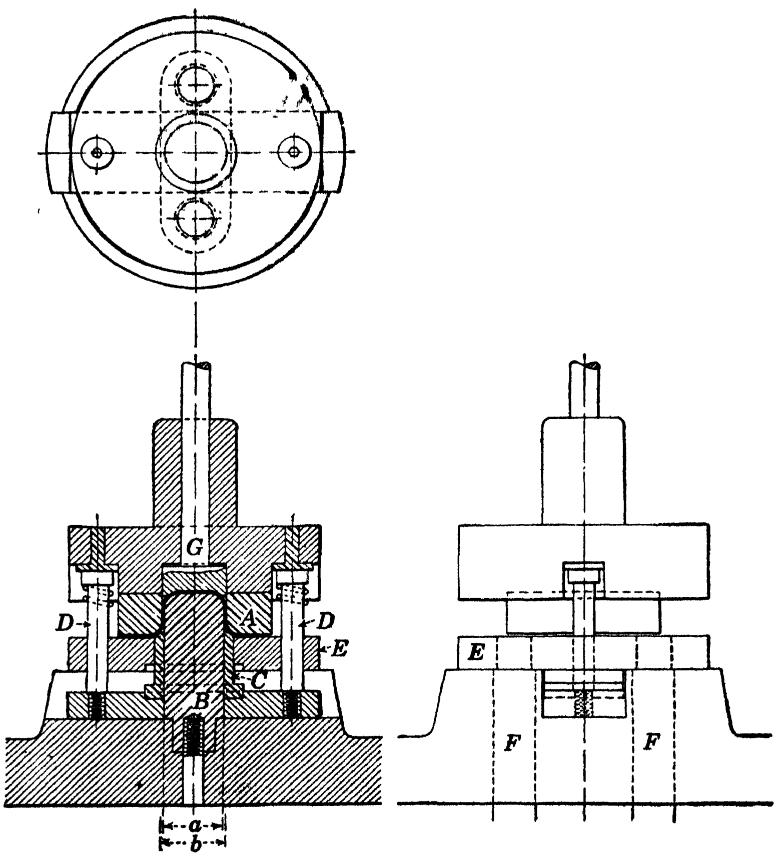


FIG. 36.—Dies shown in Fig. 35.

With reference to Fig. 36, the inverted die block A is carried by the punch head, and the drawing punch B is seated in the die shoe, where it is enclosed in a sleeve form of nest C which normally is raised to upper position by the spring-actuated shoulder screws D,D. These pass freely through the stripper plate E, which is lifted on the up-stroke by pressure rods F, extending down to a spring plate below the press. Most of these details are shown also in the photograph, Fig. 35.

The drawing dies are made with liberal radius, and the top of nest C

is well rounded to provide for easy slipping of the work over the nest into place for drawing to the next reduction.

On the down-stroke, the nest and the stripper plate *E* are carried down, and the work drawn over the inverted punch as shown in the view, Fig. 36. On the up-stroke, stripper *E* is forced up by the heavy springs below rods *F* and strips the shell from the punch. A knock-out for the die is provided in the punch head above, at *G*. As stated, the springs on screws *D* lift the nest as the punch head rises, and the next blank is then slipped over the top of the nest.

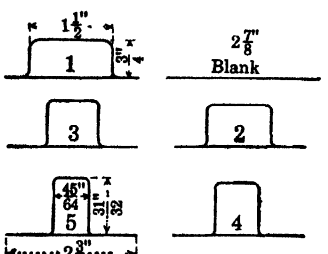


FIG 37.—Sequence of drawing operations in dies, Fig 36.

The series of dies in the outfit are identical in design, and the sizes or parts vary only with respect to diameters of drawing die *A* and punch *B*.

Locating the shells by means of the internal nests for successive drawing operations enables the shell to stay concentric with its flange, and tendency toward "offsetting" is avoided, the shell being held in true alinement with the die which effects the reduction in each instance.

A latch housing is made of 0.035 deep drawing cold rolled steel, drawn up in seven operations from the blank, including the cupping operation. The tools are made as in Fig. 38 and are used in a double action cam press.

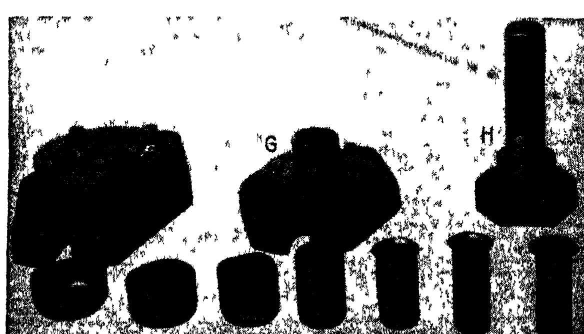


FIG. 38.—Drawing dies for latch housing.

After the first five draws, the end is turned off to square it and remove the tough metal at the open end.

The cup is 2¼ in. in diameter by 1⅛ in. deep; the final draw produces a shell 31/32 in. in diameter by 2¾ in. deep with narrow flange as shown in Fig. 39. The drawing reduces the metal thickness in the walls to about 0.032 in. The flange thickens up to 0.040 in.

The die shoe *F*, Fig. 38, appears like a plain open drawing die. The

"nest" is shown at *G*. It is secured to the cam pad or outer slide, while punch *H* is carried by the plunger. The punch slides through the nest which is brought down in action nearly to the face of the die, or so that the shell which is slipped over the nest will come nearly into contact with the die opening at the lowermost position of the pad. The punch continuing downward with the plunger then draws the shell down through the die.

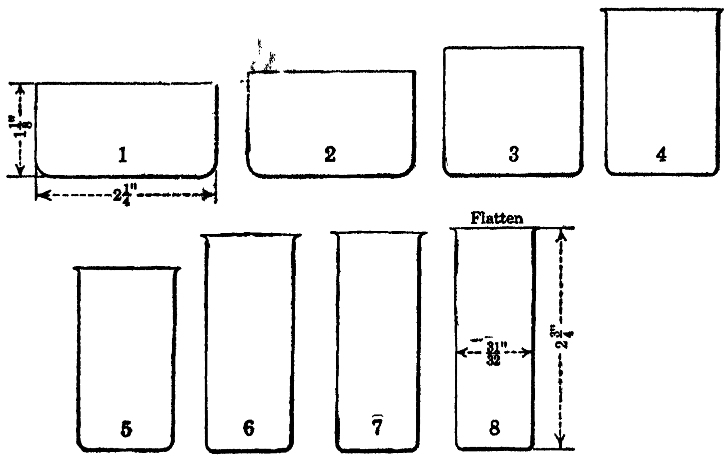


FIG. 39.—Sequence in drawing latch housing.

The shell is stripped from the punch beneath the die by three spring stripper pins located in the bottom of the die shoe.

MAKING A FUNNEL SHAPED SHELL

Thus far most of the dies illustrated in this chapter have been for producing cylindrical shells and similar articles with straight walls; but such objects form only a part of the work for which drawing dies are regularly used. They are quite as applicable to the making of conical shaped articles, square and rectangular boxes and shells, and irregular parts of too great a variety to even designate by title. Frequently the drawing process is utilized for one or more steps in a sequence involving the application of forming and bending dies, trimming tools, and other press appliances of like nature, each doing its part of the work in advancing the article toward completion.

The tools in Figs. 40 and 41 are a set for making the cone shaped or funnel formed article shown in detail in Fig. 42. This is a piece used in a coin register and it is made from 0.032-in. steel. It is three inches in diameter at the large end and at the small end there is a $\frac{25}{64}$-in. nose drawn up to a height of $\frac{1}{8}$ in.

The work starts with the production of a blank in the dies, shown in

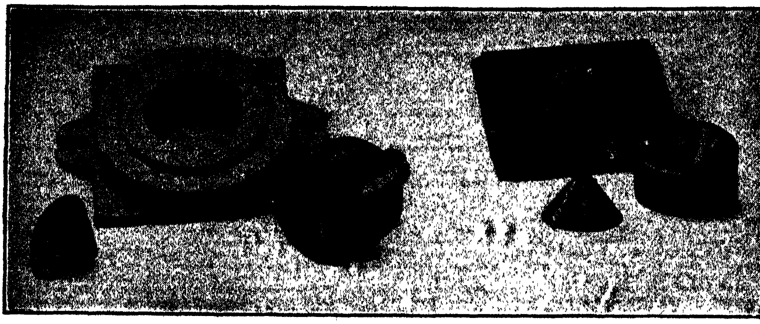


FIG. 40.—Tools for a conical shell.

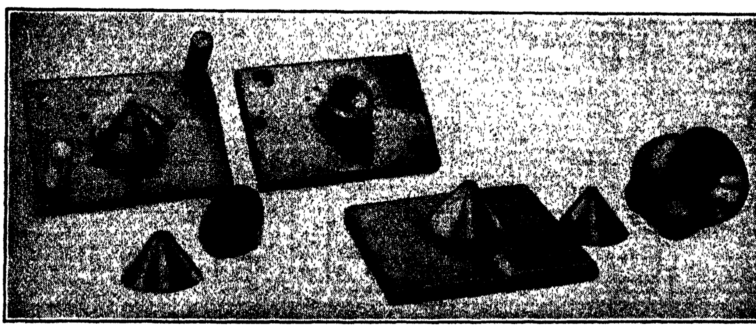


FIG. 41.—Tools for a cone shaped article.

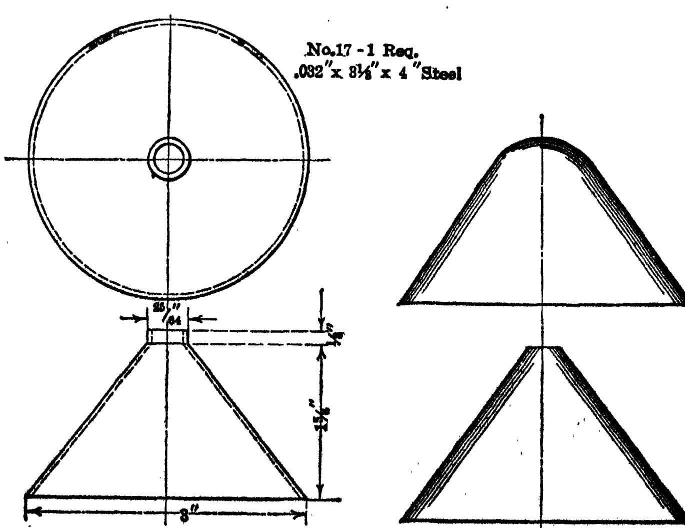


FIG. 42.—Detail of cone shell.

Fig. 40, which cut out a disk 3¼ in. diameter. Then the work goes into the dies in Fig. 41 where the flat blank is cupped or drawn up to the approximate size wanted but with the smaller end rounded to the curve indicated at *A*, Fig. 42. This end is then brought up to the form *B* and the hole pierced in the point by the tools at the right in Fig. 41, which are adapted to operate on the top half only of the work. Then the finish tools at the left in this photograph set the whole cone up firmly to the shape of the conical lower die and open the hole and finish the collar or nose on the end of the piece.

With the exception of the last set of dies all of the tools on this work are of the open type but the finishing dies are of the subpressed order or made with pillars for alinement in operation.

An Irregular Oil Can Spout

As an example of an irregular piece of drawing work the oil can spout in Fig. 43 is referred to here. This illustration represents the spout in

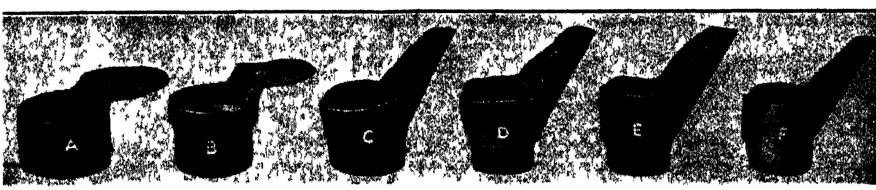


Fig. 43.—Steps in making an oil can spout.

various stages from start to finish. The tools are shown by Figs. 44 to 48 inclusive.

The drawn object is made in nine operations and two anneals. There are five draw, one stamping, and three trimming operations. The metal is brass 0.020 in. thick, the blank being 4.5 × 3.250 in. By placing the set edges *A*, Fig. 44, at 70 degrees to the center line *B-C*, a strip 4.25 in. was used as stock.

The first operation is accomplished on a small cam drawing press. Coming from this the diameter of the shell is 1.75 in. and the depth 1⅛ in. The production on this operation is 15,000 per day. It has been found that there is an advantage in making the drawing die of a separate piece of steel from the cutting die as shown in Fig. 44. When the drawing die becomes worn and has to be reground, this can be attended to by taking it apart and grinding the drawing and the cutting dies separately.

The second drawing operation is performed with a single acting reducing die, Fig. 45, the shell being reduced to 1.5 in. in diameter for 1 in. of its depth. In this operation a ratchet dial feed is used and the production is 25,000 per day.

The third drawing operation is made possible by the reducing die, Fig.

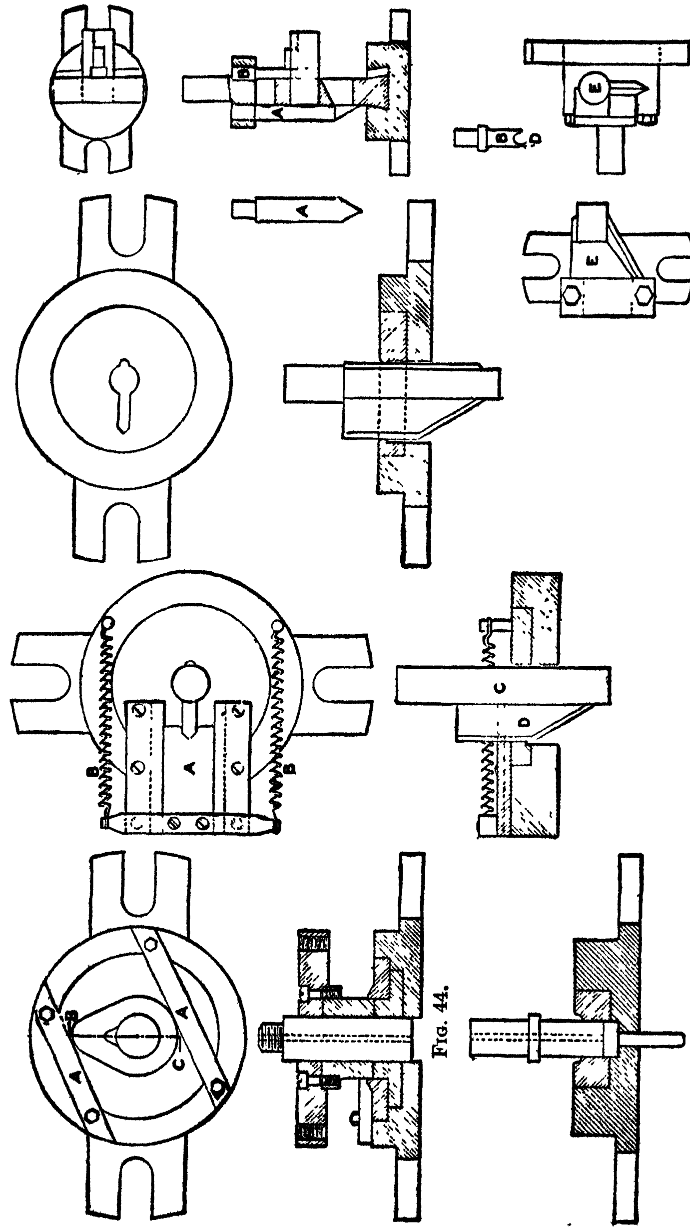


FIG. 44. FIG. 45. FIG. 46. FIG. 47. FIG. 48.

FIGS. 44–48.—Details of drawing and trimming dies for an oil can spout.

46, having the slide *A* placed on the side where the spout is to be formed. This slide has tension on it caused by springs *B*. As the punch *C* descends the lip *D* presses against the metal left to form the spout which pushes the slide *A*. This slide, acting upon the principle of a jumper ring in a combination drawing die, keeps the metal smooth in the spout while it is being formed to shape. In this operation a ratchet dial feed is used and the production is 25,000 per day.

The fourth operation is done in a single acting reducing die like Fig. 45. The shell is here reduced to 1.25 in. in diameter for 0.5 in. of its length. The same type of feed is employed as for the previous operation and the same rate of production is obtained.

The fifth operation is performed with the reducing die, Fig. 47. The cylinder of the shell is reduced to 1.25 in. diameter. Feed and production are as before. The sixth operation is performed in a stamping die set in the crank press. Here again the same ratchet feed is used and the same rate of 25,000 pieces per day is obtained.

The trimming of the shell is done in three operations: First the nose and air vent are trimmed in one operation by the punches *A* and *B*, Fig. 48, the punch *A* being made with a V-shaped cutting edge to fit the spout, and the punch *B* with a cutting edge to fit the air vent of the shell. In the second trimming operation one side is trimmed in the die *E*, Fig. 48. The third trimming operation is performed in a die similarly made, but the reverse of die *E*.

Foot presses are used in all of the trimming operations and a production of 10,000 a day is secured with each operation. Soap water is the lubricant used on all of the drawing operations.

Peculiarities of Square Drawing Dies

Reference may be briefly made here to some of the special features in the construction of drawing dies for square and rectangular work. Improper tool designing for boxes of these forms will more seriously affect the product than in the case of plain cups and shells, and the following suggestions may be of service to those who now and then have work of this nature to look after.

Difficulty is frequently encountered in drawing rectangular shapes even though the tools may be to all appearances excellent examples of that class of die work, due principally to the fact that the radii of the corners and edges are not given due consideration. These radii are of the greatest importance when designing such tools and should be made as large as the shape to be drawn will permit. The drawing at the sides of the work is similar to a bending operation and the greatest stress upon material and tools occurs at the corners of the die. Should a box be required in which a corner radius of $\frac{3}{4}$ in. is permissible it is unnecessary to make it smaller.

The quality of metal used should receive due consideration, and in case of failure a set of dies should not be too hastily condemned or the operation pronounced impracticable when it may be the material that is at fault.

The radius of the drawing edge of the die should be uniform and smooth, the corners very hard and the top surface entirely free from grinding marks. Slightly more than the required amount of material thickness should be allowed for at the corners, as this reduces the amount of pressure and consequent wear on the die which will occur principally at these points. As stated, the radius of the drawing edge should be as large as possible, but if material is released from under the pressure pad or blank holder too rapidly, wrinkling will take place, probably resulting in fracture of the material or in jagged corners. For thick stock this radius can be quite large, but for thin stock it should be small. A good rule is to make the radius about six or eight times the thickness of the material used.

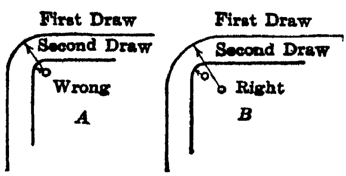


FIG. 49.

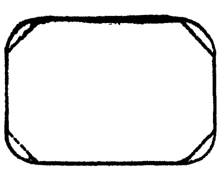


FIG. 50.

FIGS. 49–50.—Corners in square and rectangular dies.

When it is not practical to draw a box in one operation the corner radius of the first draw should be approximately four times the required radius of the finished shell. In order to illustrate more clearly the right and wrong method of design, the corner radius of first and second operation dies is shown in Fig. 49. At *A* the radii for both operations are drawn from the same center. At *B* is shown the proper method. Note that the radius is described from a different center for each die.

When a die maker not familiar with this class of work is called upon to determine the required blank size he not infrequently makes the trial blank as shown by full lines in Fig. 50, but after repeated trials he will reach the conclusion that the shape as shown by dotted lines is more nearly correct. A method of eliminating some of these trial blanks and arriving at once at the proper shape and size for work of this character will be found in another section of this book relating directly to the finding of blank sizes and to layout operations in general.

Drawing Work Inside Out

It is occasionally desirable to redraw work by turning it inside out, thus securing a greater degree of elongation at each operation. An example of a shell made in this manner is illustrated herewith with the dies for

performing the series of operations required in making this shell, which finishes to a length of $6\frac{3}{4}$ in. and an inside diameter of $1\frac{13}{16}$ in., the wall being 0.028 in. thick. The material is Britannia white metal.

The work is performed in four dies and comes out of the operations with a highly polished surface. The dies are shown in Figs. 51 to 54 inclusive with the progress of the shell indicated in each view by a detail sketch.

These sketches of the dies are practically self-explanatory but a brief outline of the operations may be of value. The cutting and drawing dies,

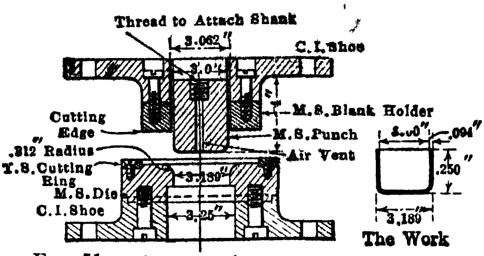
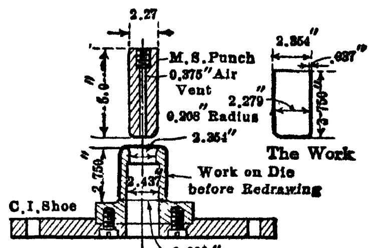


FIG. 51. 1st Operation Cut and Draw Dies



2nd Operation 1st Redraw Die FIG. 52.

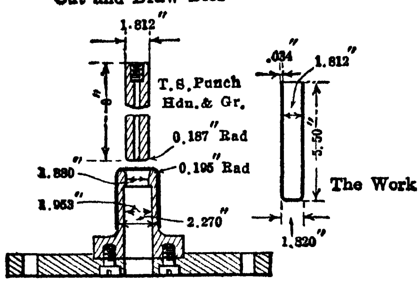
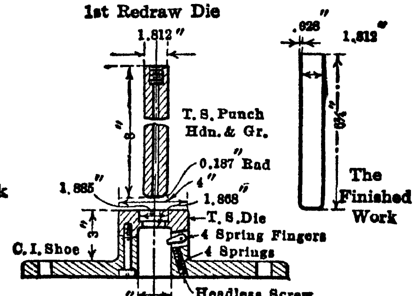


FIG. 53. 3rd Operation 2nd Redraw Die



4th Operation 3rd Redraw FIG. 54.

FIGS. 51–54.—Drawing tubes inside out.

Fig. 51, are used in a double action press with a blank $6\frac{1}{4}$ in. square and 0.094 in. thick. These first dies give a cup 3 in. in diameter by $2\frac{1}{2}$ in. high but do not thin down the walls at all as the difference between the punch diameter and the die is made just twice the thickness of the blank.

During some earlier experiments with this work good results were secured until the final operations were reached; then the percentage of broken pieces would be anywhere between 50 and 75 per cent, sometimes more. That was with the ordinary method of redrawing. Then it was decided to try to turn the preceding cup wrong side out, so the second and third operation redrawing dies were made on that principle and thereafter there was practically no trouble.

The second, third, and fourth dies can be used in any ordinary single action press, provided the stroke is long enough.

The dies, Fig. 52, for the second operation bring the walls of the tube down to 0.037 in. thick and lengthen it to $3\frac{3}{4}$ in. The cup after passing through the first operation dies is inverted over the die for the second operation. This die is made 0.010 in. smaller on the outside than the inside diameter of the work to facilitate matters when feeding, as the press can be run continuously, the work dropping down through the center of the die into a box.

Third and Fourth Draws

The third operation, Fig. 53, consists of the same operation as in the second, only the die is made to draw the work down to the required inside diameter with walls 0.034 in. thick, giving a shell $5\frac{1}{2}$ in. long.

The punch for the third operation is used on the fourth or final draw, and the die is made as in Fig. 54. This completes the work, making a shell or tube $1\frac{3}{16}$ in. diameter, $6\frac{3}{4}$ in. long, and 0.028 in. thick through the walls, with a high polish on the outside. Of course the die has to be highly polished to give these results, and the punch is hardened, ground, and lapped as the work after passing through this last die holds tightly to the punch.

The dies for the first, second, and third operations are made of machine steel and left soft, but polished, and the cutting ring for the first operation is of tool steel but is not hardened.

The work automatically strips itself from the punches in the first three operations, as there is a little outward spring to the top walls of the work. In the last-operation dies, four spring fingers are placed around the die, to just let the punch through without touching. When the work is on the punch, these fingers spring downward and over the top, thus stripping it off the punch on the upward stroke.

The only lubricant used on these four operations is a mixture of soft soap, soda, lard oil, and water all boiled together and left to cool before using.

The uneven ends of the work are not trued up between operations, as this is unnecessary and would only waste stock and shorten the final tube. The work is not annealed or touched between operations.

Gang Drawing Dies for Steel Thimbles

As stated before, drawing dies are frequently arranged in gangs for convenience of operation and for high production. An example is seen in the accompanying outfit for manufacturing the steel thimble shown in Fig. 55 herewith.

This thimble is made of No. 14 gage cold rolled stock. It must be held close to the required dimensions and is made in five operations without annealing. The walls must be held to original thickness. By making the

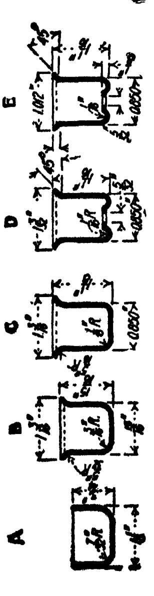


Fig. 55.

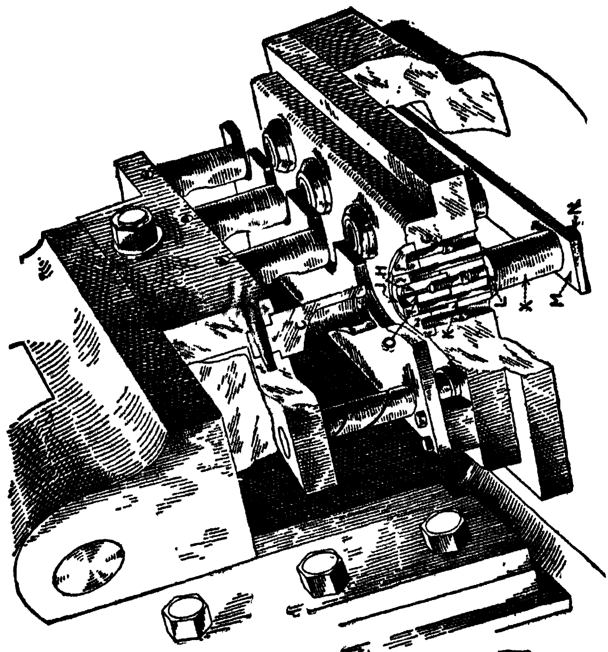


Fig. 56.

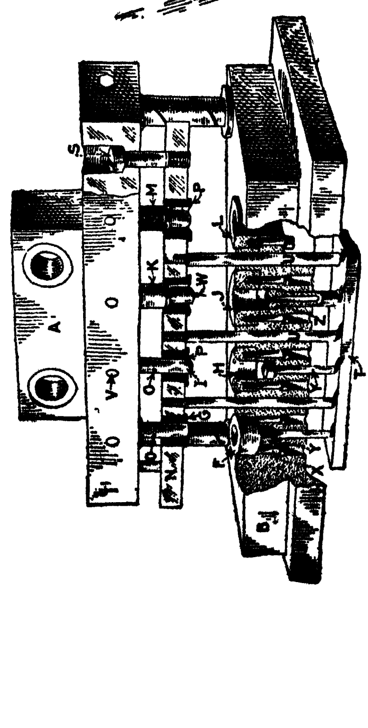


Fig. 57.

Figs. 55–57.—Gang drawing dies.

thimble in five operations the reduction is gradual and the stock is less strained, thus preventing the stretch that would otherwise occur.

Sub-press dies, or dies with guide pillars, are used to facilitate the die setting, and few presses are necessary to start the work. In this way the presses can be set up and the finished article turned out in a very short time as compared with the usual method of running a single operation on a press. The drawing dies are operated in two small presses set close together. The blanking and cupping operation is performed in an inclined press.

The punch *C*, Fig. 56, serves a double purpose. As it descends it cuts the blank, which is held between its face and the pressure plate *J*. As it descends further, the blank is forced by the punch *H* through the central hole in *C*, thus forming the cup. The pressure on the plate *J* is obtained from the pins *K* and the rubber bumper *X*. The required regulation of pressure on the plate *J* is obtained in the usual way by the stud *L* and the nut *N*. The blanking die *F* is held by screws *G*. The cup is carried up into the cavity in the punch *C* and as this die is used on an inclined press, the cups roll out of the opening at the back and into a receptacle, being forced out by the succeeding cups as they are formed. At no time are there more than two cups in the cavity.

The lower punch is vented at *O* so that the cups will strip readily. The production on this operation is 3,000 pieces per hour.

Following Operations

The second, third, fourth, and fifth operations are now put through the die shown in Fig. 57, whereby the operator transfers the operations in proper rotation from one die to another, keeping all dies supplied. The capacity of this die is 1,000 pieces per hour.

In Fig. 57 is shown the front view of the gang dies for the four final operations. The punch holder *A* and the die holder *B* are kept in proper alinement with each other by guide pins.

The shell *B* (Fig. 55) is drawn in the second operation die *F* by the punch *G*. This punch has an air hole to allow easy stripping. The shell *C* (Fig. 55) is drawn in the third operation die *H* by the punch *I*. This punch has an air hole at *O*. The shell *D* is drawn in the fourth operation die *J* by the punch *K*, a 45-degree angle flange being bulged in the bottom and a $\frac{5}{32}$ in. hole punched. The shell *E* is trimmed on the flange in the fifth operation die *L* by the punch *M*.

The stripper *N* (Fig. 57) is held in place by the screws *SS*, which are long enough to give the stripper the proper movement to release the shells from the punches with the aid of the lower knock-out plate *T*. This stripper is fitted with carbon steel bushings screwed into place. The knock-out plate *T* also releases any shells from the dies by giving the

knock-out pins Y and Z the proper movement. The stripper bolts U are adjusted in relation to the stroke of the press.

The punches G, I, K, and M are held in position by tapered pins V. The punch K has a perforating punch W inserted to perforate the bottom of the shell and must be adjusted to suit the thickness of the metal in order that it may not go through too far before the forming of the bottom takes place. The dies F, H, J, and L are held in position by the screws X. The knock-out pin Z in addition to acting as such also serves as a perforating die for the fourth operation.

Progressive Dies for an Automobile Hub

The manufacture of a pressed steel automobile hub as carried out by means of the following tools forms an interesting illustration of the application (among other types) of the progressive arrangement of dies for certain kinds of drawing operations. This steel hub, as shown in Fig. 58, is drawn from a cold rolled blank $13\frac{1}{8}$ in. diameter and $\frac{1}{8}$ in. thick. It is finished in 10 operations. Several of the dies are of the tandem order which increases production and decreases the number of presses used.

The tandem drawing dies are set upon double acting presses. They can be operated by one operator but two are required when the greatest possible output is desired. When two operators are engaged on one press, an electric device with four pushbuttons is put in action, whereby both operators must touch the four buttons in unison before the press can be brought into action by a foot treadle controlled by one of the operators. This arrangement protects both operators from being injured in any way.

As mentioned elsewhere, it is customary in most plants making pressed steel articles to draw shells with dies that have only enough clearance between punch and die for the thickness of the stock, the punch being made twice the thickness of the stock smaller than the die diameter. This is not always practicable where heavy material is drawn, where strength is more desirable and uniformity of wall thickness of less importance.

The first four operations on this hub are handled in drawing dies that are $\frac{1}{32}$ in. large. The dies work easily and keep free from scratches. This saves much time usually taken to polish the radius. The stampings release with less friction when made under these conditions and the stock being subjected to lower stress will admit of passing through more operations without annealing. The walls of the shell are apt to thicken up and this is desirable where strength is required. Necessarily, the production from dies operated under these conditions is greater.

The first two operations shown at A and B, Fig. 58, are the blanking and drawing on the dies in Fig. 59, operations 1 and 2. The stamping A when blanked and drawn is transferred from the first operation to the

second operation die, which reduces its diameter to 4¾ in. and turns the stamping completely inside out. Whenever it is possible to apply this method it should be adopted, as with it a greater reduction in diameter is effected.

The tandem dies in Fig. 59 are made of steel sections set in cast iron plates *A* and *B*. To facilitate setting up of the dies the guide pins *C* are added and held in position by the set screws *D*. The guide pins are made of hardened tool steel and are ground 0.002 in. smaller than the bronze

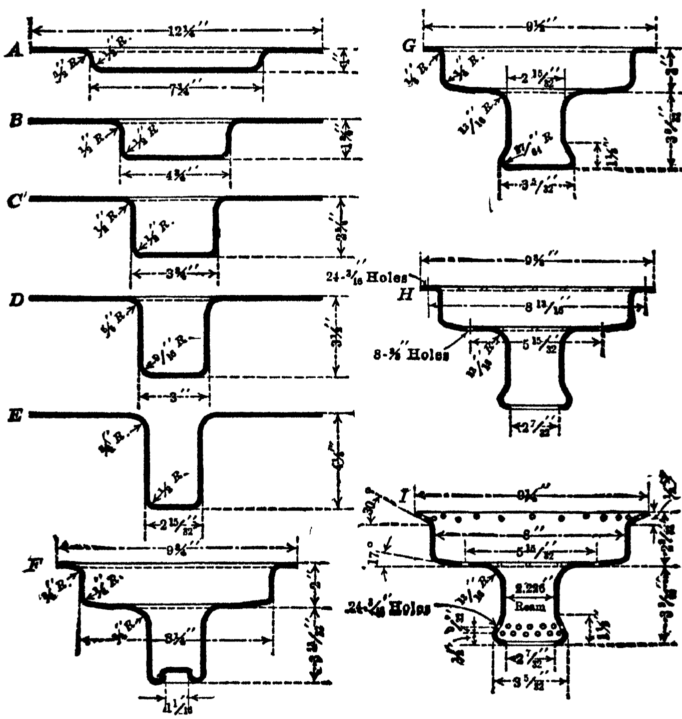


Fig. 58.—Successive steps in drawing a pressed steel hub.

bushings *E*. The bushings *E* have at *F* recesses that are filled with a mixture of machine oil and white lead to lubricate the guide pins *C*.

Referring to the first operation dies, the blanking punch *G* is held in place by the screws *K*. The blanking die *H* is held by screws *R*. Both punch and die are made of tool steel hardened. The punch *G* is hollow and allows the punch *I* to enter it as it descends. The blank from *H* and *G* is formed between *I* and *G* to the shape shown at *A*, Fig. 58. The punch *I* is held in place by the nut *L*. The pressure plate *J* is made of hardened tool steel. It prevents wrinkles in the work and at the same time acts as a knock-out to raise the work out of the die and to a position where the operator can quickly transfer it to the second operation die.

The pressure on J is controlled by the rubber bumper M. Adjustments of the pressure are made by tightening the nuts S against the plates O. Care must be exercised in adjusting this pressure pad as too much pressure on it may strain the work on the radius and cause it to break when subjected to succeeding operations.

The gages X are tool steel, hardened. The rear gage must be set to the edge of the die in order to allow the steel to part and open. This

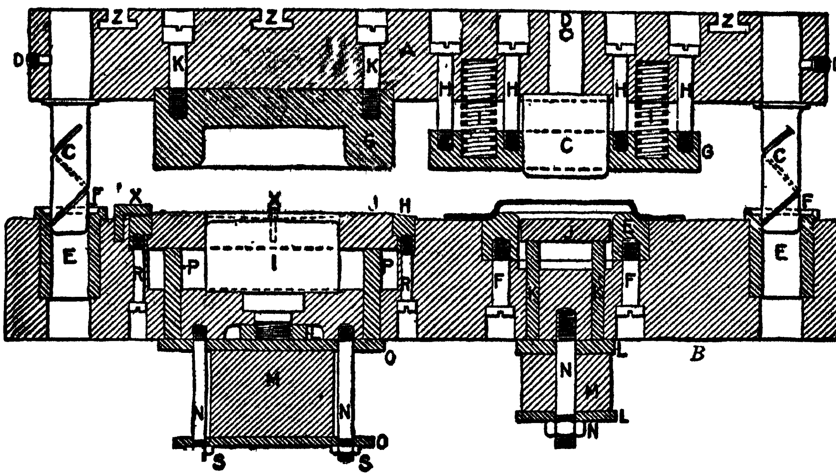


FIG. 59.—First and second operations.

prevents the steel from holding to the punch, obviating the necessity for a stripper plate on the die.

THE SECOND OPERATION DIES

The second operation dies operate in the same manner as those for the first operation. C is the punch, held in place by a taper pin D. The die E is secured by the screws F. Both punch and die are made of tool steel, hardened. The stripper G acts also as a pressure pad and is held in place by the screws H. It is given the proper pressure and ejecting action by the springs I. The knockout J, which discharges the stamping from the die is made of tool steel, hardened. It is actuated by the pins K and plates L when the rubber bumper M is properly adjusted by the bolt and nut N.

The shoe A has T-slots Z to fasten it to the ram of the press. The stampings CDE, Fig. 58, are reduced from $4\frac{3}{4}$ to $2\frac{15}{16}$ in. diameter in three operations. The work is drawn on tandem dies shown in Fig. 60. This die also is operated in a double crank press. The shoe or punch casting A is made of cast steel and the shoe B of cast iron set with steel dies and punches. These are guided by the pins C, held by set screws D,

and ride with the necessary freedom in the bronze bushing *E*. The dies *H* are of tool steel, hardened; they are held in place by screws *I*.

The stripper plate *J* has hardened bushings *K* which act as pressure pads to flatten the flanges of the work. The stripper is held by the bolts *M*, which carry the lower plate *N*. This lower plate is so adjusted that it gives the shoulder knock-out *O* the proper travel to expel the stampings

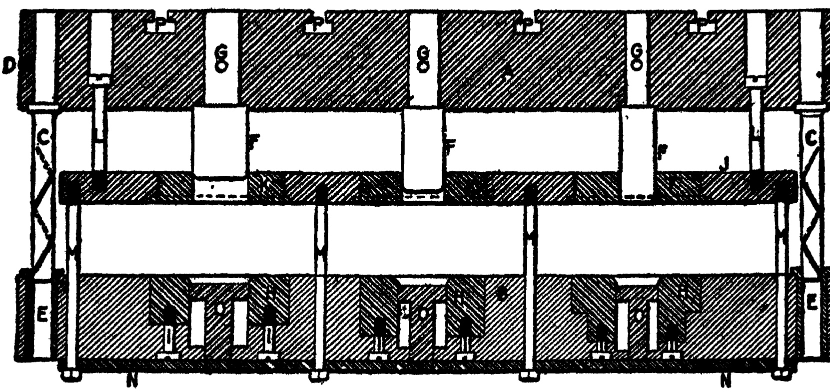


FIG. 60.—Third, fourth, and fifth operations.

CDE, Fig 58, when the ram is on its upward stroke. The T-slots *P* are for securing the punch to the ram of the press.

THE SIXTH OPERATION DIES

The stampings *E* are now annealed and pickled to remove all scale before they are put through the sixth operation dies, shown in Fig. 61. Here they are formed into a hub 8¼ in. in diameter and the bottom is indented. The indentation die is necessary to shorten the hub to fit the succeeding die, as well as to supply the much needed stock that is necessary for bulging in a later operation.

At *A*, Fig. 61, is the punch, which is made of tool steel, hardened. The stud *B* has a hole *X* through the shank to secure it to the ram. It is threaded on the opposite end to hold together the sections *BCD*. The shoe *E* is of cast iron and serves to hold the dies that are made in sections. The forming die *F* is secured by screws *G* and is of tool steel, hardened. The bushing *H*, held by screws *I*, is also of hardened tool steel and serves to guide the hub in its downward course to indent the bottom with the tool steel hardened punch *J*. A tool steel hardened ring *K* acts as a knockout, should the hub stay in the die. The stripper *L*, which also serves to flatten the flange of the hub, is made of machine steel and has a hardened tool steel ring *M*, which is held in position by screws *N*.

The stripper *L*, which is free to slide on the punch *A*, must be held to the ram by bolts and given the proper sliding adjustment. The tapped

holes *O* are provided for securing it to the press ram. The rods *P* are screwed to the stripper pad *L* and carry the knock-out plate *R* underneath the die.

The knock-out ring *K* is fastened to the plate *R* by the bolts *S* and when properly adjusted works as a unit in connection with the stud *J* to

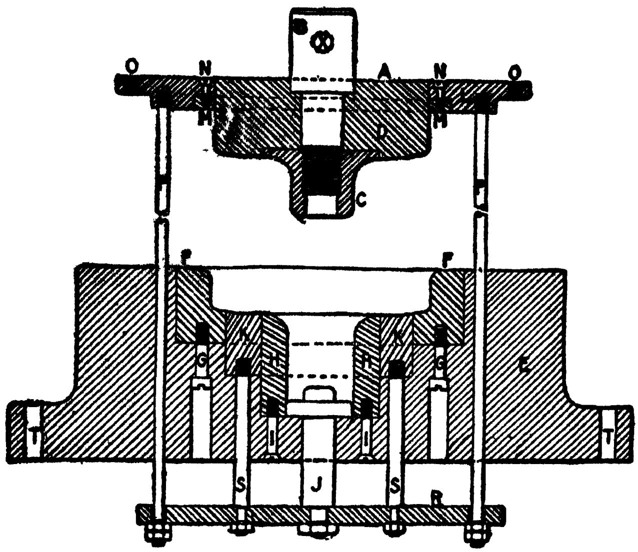


FIG. 61.—Sixth operation.

release the hub on its upward stroke. The holes *T* in the die serve as a means for bolting it to the press.

THE BULGING PROCESS

The hub *F*, Fig. 58, is now put through the oil bulging dies. This is the seventh operation and is shown in Fig. 62. The end is bulged out until it fills the cavity *Z* in the die, forming the necessary end. The flanges are also squared in this operation. The hub should be 0.010 in. small at *O* in the dies, so that the punch *X* when entering the hub will expand it to size. There being no escape for the oil because of the tight fit of the punch in the work, the hub will be bulged out until it fills the cavity *Z* in the die.

The punch *A* is made of machine steel with a hardened plate *B* held by the screws *C*. This plate serves to flatten the flanges on the hub. The holes *D* are drilled in the punch and serve to discharge the oil from the upper part of the hub. The point *X* is made of high-speed steel and can be replaced quickly when, through wear, this becomes necessary. In addition to the ram adjustment the adjusting screws *E* and the rubber washer *F* must be set with care in order to regulate the amount of oil

necessary for bulging. If the set screws *EE* are too high in the punch, the pressure in the bottom of the hub is decreased to such an extent that it will not fill the cavity *Z*; and if the screws are too low in the punch, there is too much pressure, which might result in damage to either the press or the die or both.

The die shoe *G* is of cast iron and serves as a reservoir and die holder. The die *H* is made in halves and is opened by the cam *I* and a square sliding pin *J*, assisted by the springs *K*. Oil channels large enough to discharge the surplus oil are provided at *L* in the die as well as at *D* in the punch. The inlet and outlet pipes *M* and *N* must be so placed as to give

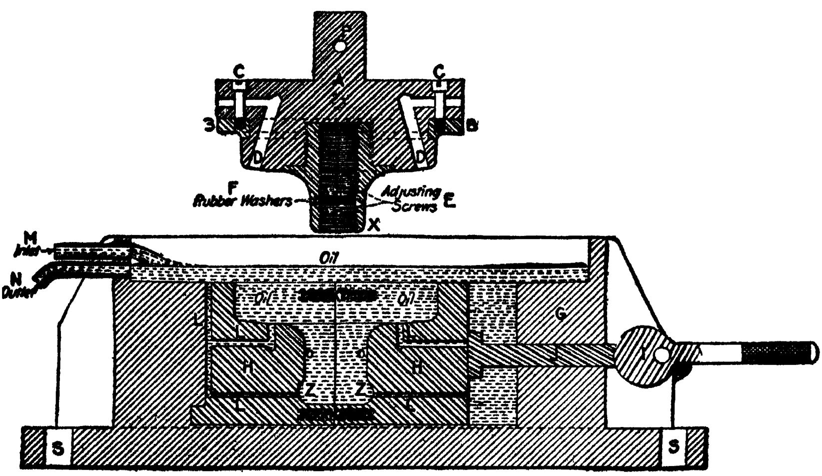


FIG. 62.—Seventh operation.

at all times the proper depth of oil in the reservoir. These pipes are supplied with lard oil through properly adjusted automatic pumps. The punch is secured by a pin through the hole *P* in the shank. The holes *S* in the die serve to secure the die to the press.

PERFORATING OPERATIONS

The hub *G*, Fig. 58, having been finished on the bulging die, is now ready to be perforated in the eighth operation die, shown in Fig. 63. The punch *A* is of cast steel, has twenty-four $\frac{3}{16}$-in. punches *O*, eight $\frac{1}{4}$-in. punches *X*, and one $2\frac{7}{32}$-in. punch *Z*.

The small punches *OX* are made of tool steel, hardened. They are driven into place and have shoulders backed by the hard plate *N*. The punch *A* has guide pins *B* secured by screws *C*. The guide pins work in bronze bushings *D* seated in the cast iron die plate *E*. The die plate *E* has 33 dies pressed into place. These correspond to the punches. The dies *F* and *G* are of tool steel and hardened.

The large bushing H is made of tool steel, hardened, slightly tapered, and pressed in place. The small and large punches are staggered so as to use as little power and be as easy on the dies as possible. The large punch

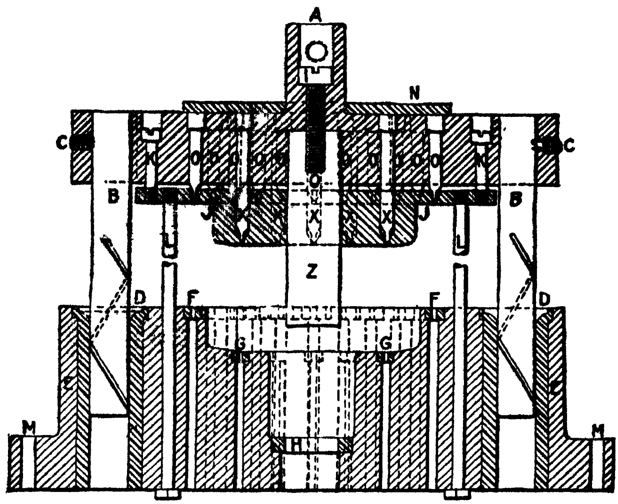


Fig. 63.—Eighth operation.

Z is made of tool steel, hardened and held in place by the screw I. The stripper J is made of machine steel and is held in place by the screws K that slide in the punch with enough freedom to allow the stripper to disengage the hub from the punches. The stripper bolts L must be adjusted

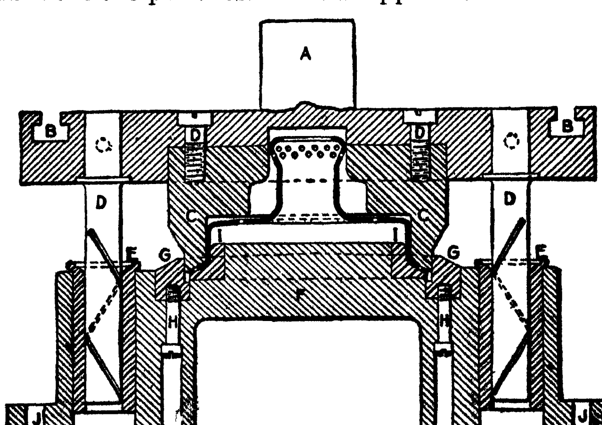


Fig. 64.—Ninth operation.

to suit the stroke of the ram. The holes M are for bolts to secure the die to the press bed.

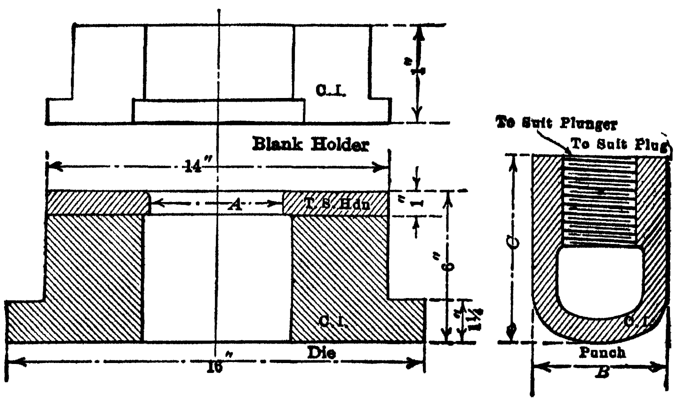
The hub H, Fig. 58, having been perforated, is now trimmed on the flange and beveled, which concludes the press work. This operation is

performed on the ninth operation die shown in Fig. 64. The punch holder *A* is made of cast iron and has a stud and two T-slots *B* to secure it in the ram. The holder *A* is counter-bored to seat the hardened tool steel, hollow trimming and beveling punch *C* which is secured by screws *D*. The guide pins *D* slide in bronze bushings *E*. The die plate *F* is of cast iron and seats the tool steel trimming die *G*, which is held by screws *H*.

The ring *I* is of tool steel, hardened and pressed on *F*. It acts as a beveling die. The last operation consists in drilling the small spoke holes in the bulged end of the hub and is performed in the drill press with the aid of a jig.

Drawing Large Work of Aluminum

Details of punches and dies are given in Fig. 65 as used in a heavy toggle press in the drawing of aluminum ware with double acting dies.



Dimensions of Tools

1st Op. Die	1st Op. Punch	
$A = 8\frac{1}{16}''$	$B = 8\frac{5}{16}''$	$C = 6''$
2nd Op. Die	**2nd Op. Punch**	
$A = 6\frac{9}{16}''$	$B = 6\frac{7}{16}''$	$C = 10''$
3rd Op. Die	**3rd Op. Punch**	
$A = 5\frac{5}{16}''$	$B = 5\frac{3}{16}''$	$C = 15''$

Fig. 65.—Tools for drawing aluminum ware.

The blank has been prepared in a previous operation and is located against a couple of low stop pins in the face of the die near the rear edge. In some sizes the equipment is arranged for blanking and drawing in the first operation, as is so commonly done with shell work in general. But in this instance the outer slide of the press is fitted with a pressure plate or blank holder which is not provided with a cutting edge but instead is used under the double acting arrangement to apply the requisite pressure to

the blank to prevent it from wrinkling while it is being carried down into the die.

When the outer slide of the press is at the bottom of its travel, the pressure plate holds the work under suitable pressure while the punch is carried down by the inner slide or plunger. When outer slide and inner plunger are rising from the work, the punch of course is well cleared before the pressure plate or blank holder lifts; and when both are in their uppermost position, the work is ejected from the die by the lower knock-out.

The drawing, Fig. 65, gives the dimensions of the dies in the outfit and the sizes of the punches. The work is made from 16-in. aluminum and is not reduced in thickness during the drawing process. The blank is $13\frac{1}{2}$ in. diameter at the start and the first draw forms it into a shell $8\frac{7}{16}$ in. outside diameter by 3 in. deep. The second operation lengthens it to $5\frac{1}{4}$ in. with a diameter of $6\frac{1}{2}$ in. and the third draw produces an article $5\frac{3}{8}$ in. diameter by 6 in. deep.

The die proper is a hardened tool steel disk 1 in. thick which is screwed to the top of the die bolster. The radius on the drawing edge of the first operation die is $\frac{3}{8}$ in. or six times the thickness of the material drawn. The punches are hollow as indicated and are cast iron cored to the interior form shown. They are threaded at the upper end to suit the press plunger. Their lengths are given in the table under the detail sketches.

Cast Iron Dies

On some work of this character at different shops the aluminum is drawn in cast iron dies, that is without the steel die shown on top of the bolster. It has been observed in connection with such practice in certain places, that the cast iron die works satisfactorily so far as general results are concerned and it is the belief of some operators that the surface of the cast iron holds lubricant better and results in a better general finish for the surface of the object drawn. On the other hand, the cast iron is more quickly subject to surface wear and if the articles drawn have to be held closely to diameter this feature is an objection, particularly where large quantities of similar parts are produced.

With fairly limited runs, wear has been found negligible as observed over a reasonable length of time. With certain classes of work not fitting together, any reasonable degree of wear on the die may be overlooked entirely so long as the work is satisfactory from the point of view of appearance.

In this connection it may be stated that cast iron punches and dies have been used successfully for drawing steel shells of moderate size and so far as records go they have stood up to the work as long as the run

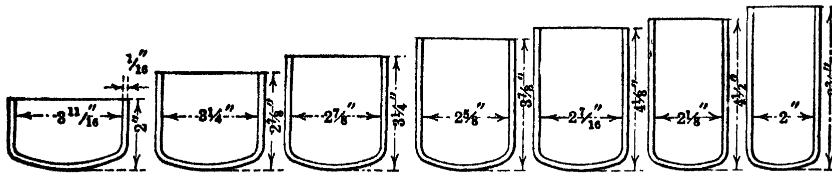


FIG. 66.—Seven operations on cold-rolled steel shell drawn with cast iron punches and dies.

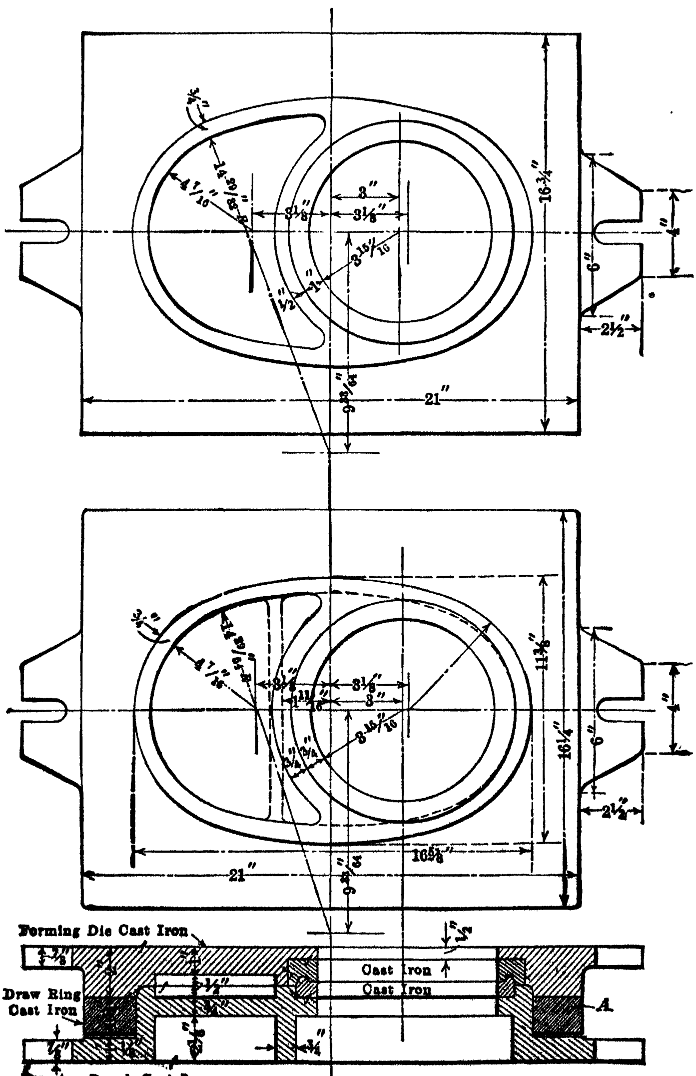


FIG. 67.—Tools for large metal cover.

lasted. Naturally they were not made in the first place for as extended a period of service as one would expect of a set of standard tool steel dies of the same proportions. But for a fairly large lot of shells on a special order they have given every satisfaction.

The drawing, Fig. 66, illustrates the successive stages of a steel shell drawn up by seven pairs of cast iron punches and dies from a blank $\frac{1}{16}$ in. thick. The cupping or first operation set and the drawing dies and punches are of simple open design. The modification in the shell as it progresses from cup to completed form is shown with over-all dimensions in Fig. 66.

These shells all appear as smoothly drawn as if the work were done in the usual steel dies. There is no reduction in the thickness of the walls of the work as the drawing is carried along and all punches are smaller than die diameters by twice the thickness of the material.

Larger Sizes of Dies of Cast Iron

When we reach the larger sizes of work, such as sheet metal containers and covers of various kinds, there are numerous occasions upon which cast iron drawing tools are made use of.

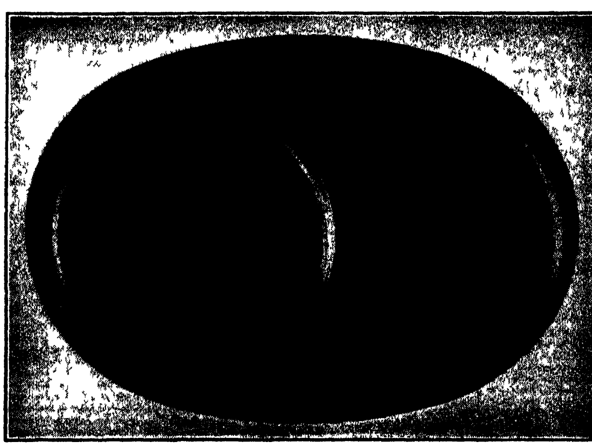


Fig 68.—The work produced in the dies in Fig 67.

Thus, Fig. 67 is a shallow drawing and forming outfit for the thin sheet cover, Fig. 68, which is drawn up from $\frac{1}{32}$-in. black iron. The dimensions on the drawing show the length of the oval shaped piece to be $16\frac{5}{8}$ in. The draw is very little in this instance, say $\frac{1}{4}$ in. or so for the edge with a forming depth for the circular portion of about $\frac{3}{8}$ in.

The cast iron draw ring *A*, which acts as a pressure ring for holding the stock against wrinkling, is controlled by a series of vertical pins that extend down through openings in the press bed and rest upon a spring

plate secured beneath the press for use with drawing dies of this character. This makes it unnecessary to apply a special pressure device with each die or type of die.

Another set of dies made of cast iron and used on this form of press are illustrated at *A*, Fig. 69. These dies perform the operations of drawing,

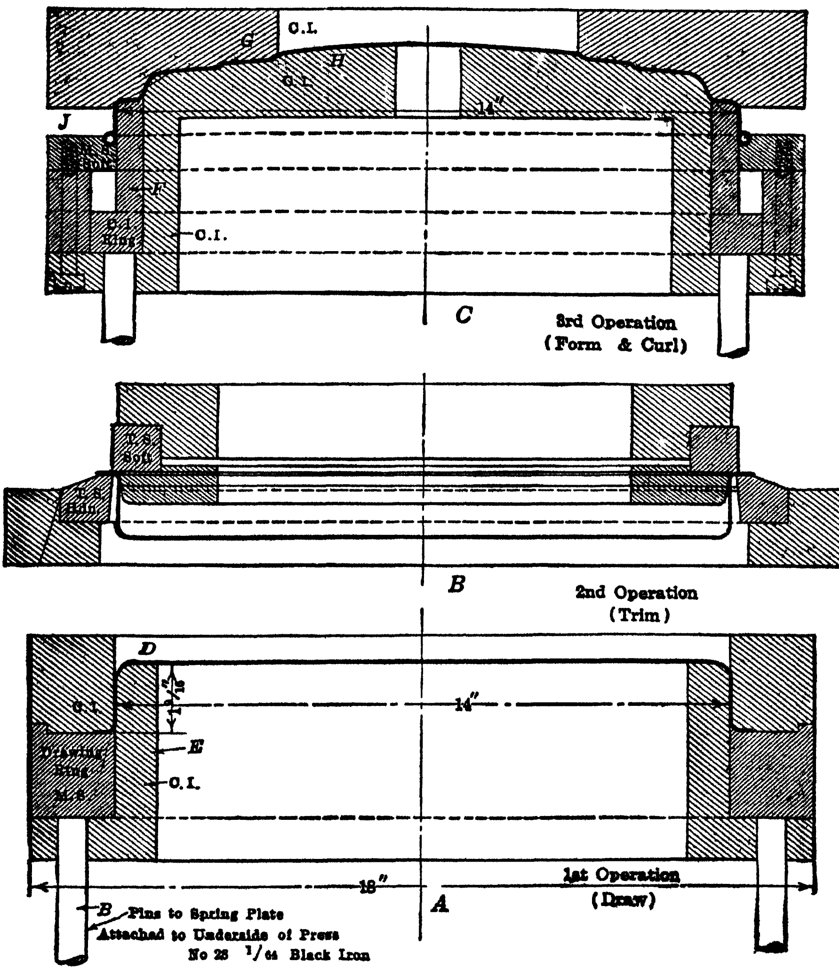


FIG. 69.—Dies for a large cover.

preparatory to the trimming and curling of a metal cover finishing 14 in. inside diameter. The same style of tools are also used for even larger work of similar character.

The metal drawn is No. 28 gage ($\frac{1}{64}$) black iron. The draw from the blank is $1\frac{9}{16}$ in. deep and a flange is left by drawing tools *A* for trimming and wiring in succeeding operations. In the drawing dies, the pressure

ring (which is supported by the pins *B* extending down through the bed of the press to the spring plate beneath) is made of machine steel but the actual drawing members *D* and *E* are cast iron only.

The steel drawing ring which is, of course, left soft, is recessed across its upper face to form a seat or retaining chamber for the blank. As the upper die descends, this drawing ring is forced down against the upward pressure of the spring plate under the press and has the effect of ironing out the metal and preventing the forming of a wrinkled surface on the work. Thus the full depth of $1\frac{2}{16}$ in. is drawn down over the lower die without difficulty. Then the work is placed in the trimming dies *B*, Fig. 69, for the shearing off or trimming of the edge around the piece.

These trimming dies have tool steel cutting edges in the form of rings of about $1\frac{1}{4}$-in. section, which are made of tool steel, the lower one being hardened, the upper left soft. The former ring is pressed into its seat around the cast iron base; the upper ring is bored a trifle under size, warmed enough to expand slightly, then placed over the shoulder on the upper die and allowed to cool and shrink in place. As these tools become worn, they are corrected by expanding the soft upper ring by peening with a hammer and refinishing by grinding to size.

The forming and curling dies are at *C* in the same drawing. When the work is placed in the dies, it rests upon the top of cast iron ring *F* which is held up by the spring plate below the press bed. When the top die *A* descends, it forms the upper face of the cover to the form of the dies *H* and at the same time the work is put under pressure by the action of ring *F* so that as the upper die continues to descend and takes the pressure ring along with it, the work is supported properly and forced to curl around the concaved groove cut around the entire circle of the ring *J*. The latter ring the curling member, is of machine steel, and supported at suitable height by being secured to the top of a spacing ring.

CHAPTER XI

OTHER DRAWING DETAILS AND METHODS

This second chapter relating to drawing dies and their applications is devoted largely to the handling of various types of materials and includes with other data some further particulars connected with shell drawing operations and similar undertakings. Thus, Table 1, covers draw reduction ratios for round shells and is accompanied by detailed rules for drawing such work.

RULES FOR DRAWING ROUND SHELLS[1]

In producing round shells without flange, the factors that govern the possible height of single-operation drawing of a shell are

1. Ratio of height to diameter of shell
2. Ductility of the material
3. Corner radius

When drawing a round shell (without flange) in one operation, the maximum ratio of height divided by diameter may vary between $\frac{1}{4}$ and a possible $\frac{3}{4}$, depending on the corner radius and ductility of the material. A generous corner radius helps to secure greater height in one operation, while too small a corner radius may cause the shell to fracture at the radius. Soft, ductile material will permit drawing to a greater height in one operation.

Ductility of materials is measured as percentage of elongation in 2 in. or percentage of reduction of area. In general, such materials as deep-drawing steel, annealed sheet steel (SAE 1005–1015), dead-soft cold rolled strip steel (SAE 1010–1020), some stainless steels (304, 410, 420 and 430), soft-temper aluminum (2SO, 3SO and 53SO), and soft-temper brass and copper will allow drawing to a maximum height in one operation. Other less ductile materials may require one or more precupping operations; that is, additional drawing dies for gradually reducing the blank to the diameter required, and possibly annealing between operations.

Corner radius of the shell has a considerable effect on the possible height of single-operation drawing. Corner radius should, when possible, be specified at a minimum of four times thickness of material when the height of the shell exceeds one-third of the diameter. When a smaller radius is specified, additional drawing or flattening operations may be required. In no case should the corner radius be less than thickness of material for a one-operation draw.

[1] Courtesy of Dayton-Rogers Mfg. Co.

When the ratio of "height divided by diameter" exceeds $\frac{5}{8}$, it will be necessary in most cases to reduce the flat blank to the finished shell by using two or more draw dies of proportionately decreasing diameters. In some cases, one or more annealing operations will be necessary between first and finish draw operations. The necessity of annealing depends to a large extent on the workability of the metal being drawn.

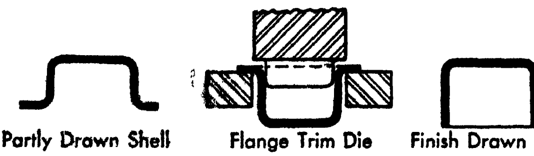


FIG. 70.—Flange and finish draw. Satisfactory for most shells. One additional die for trimming required.

Determination of the number of reductions necessary to draw a shell with ratios (height divided by diameter) greater than $\frac{5}{8}$ cannot be done by hard and fast rules. In general, for ductile materials, with generous corner radius in the shell, the requirements are

1. Height equals $\frac{5}{8}$ to $1\frac{1}{8}$ times the diameter of the shell—two reductions will be required.
2. Height equals $1\frac{1}{8}$ to 2 times the diameter of the shell—three reductions will be required.
3. Height equals 2 to 3 times the diameter of the shell—four reductions will be required.

It may be necessary to anneal the shell when more than two reductions are required. When corner radius is less than four thicknesses of material, add one or two flattening dies and operations, depending on corner radius desired.

For less-ductile materials, it is more difficult to predict the number of operations required. In general, the measure of ductility of the material (percentage of elongation or percentage of reduction of area) will determine the maximum reduction possible in one operation.

Finish of edge depends on the "height divided by diameter" ratio and on the material being drawn. For relatively shallow shells where the "height divided by diameter" ratio is not over $\frac{1}{8}$, it is possible to produce an edge within commercial tolerances without requiring finishing operations, that is, the height and uniformity of the edge depends on the size of blank used. For higher shells it is not possible to do this, and one of the following finishing operations will be required:

1. Flange trim and finish draw (Fig. 70)
2. Pinch trim (Fig. 71)
3. Machine trim Fig. (72)

A Draw Reduction Table, Table 1, offers a simple means of determining percentage of draw reduction and flat-blank diameter. By dividing the inside shell height by the mean shell diameter, a height-diameter ratio is obtained. Find this ratio in column I of the table. Directly opposite in column II find the percentage of reduction of diameter (a measure of the amount of cold working to be done in drawing the flat blank into a shell). Directly opposite in column III, find the blank-draw ratio. Multiply the mean shell diameter by this factor to obtain the approximate flat-blank diameter.

It must be understood that this table can only be used with round straight-sided shells or cups. Shells or cups with flanges must be inves-

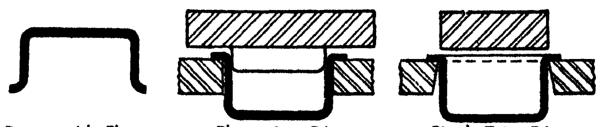


FIG. 71.—Pinch-trim die. Produces shell with uniform height, but inside edge is considerably rounded. The flange must be flattened to a sharp corner, requiring one or two sides.

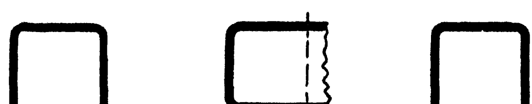


FIG. 72.—Machine or box trim. Tooling cost low but method slow. The best appearing edge is produced.

FIGS. 70–72.—Edge-trimming method.

tigated by other methods. Care must be used when attempting to predict the number of operations required to produce a flanged shell or cup.

DRAWING STAINLESS STEEL AND OTHER MATERIALS

In Chapter III a considerable amount of space is devoted to the important subject of punching and blanking stainless steel. Valuable data on methods and tools for drawing this material, as described by the same author,[1] are taken up in the present chapter, which is confined entirely to drawing operations on various classes of materials.

It is emphasized that high ductility of chromium-nickel stainless steel provides good deep drawing qualities, but the high strength and tendency to work hardening indicate modified procedures and greater power requirements. Straight high-chromium steels of lower ductility and tendency to become brittle at high temperatures can be drawn, but may require more intermediate annealing.

[1] Harold J. Flynn, *American Machinist*

TABLE 1.—DRAW-REDUCTION RATIOS FOR ROUND SHELLS*†
(Without Flange)

Shell height = inside height of shell
Shell diameter = inside diameter of shell plus one thickness of material

Height-diam. ratio	% reduction of diam.	Blank-draw ratio	Height-diam. ratio	% reduction of diam.	Blank-draw ratio	Height-diam. ratio	% reduction of diam.	Blank-draw ratio
0.01	2.0	1.02	0.48	41.5	1.70	0.95	54.4	2.194
0.02	3.8	1.03	0.49	41.9	1.72	0.96	54.5	2.201
0.03	5.5	1.05	0.50	42.3	1.73	0.97	54.7	2.208
0.04	7.1	1.07	0.51	42.7	1.745	0.98	54.9	2.216
0.05	8.7	1.09	0.52	43.1	1.758	0.99	55.1	2.224
0.06	10.2	1.11	0.53	43.5	1.770	1.00	55.3	2.231
0.07	11.5	1.13	0.54	43.8	1.780	1.05	56.2	2.28
0.08	13.0	1.15	0.55	44.2	1.790	1.10	57.0	2.32
0.09	14.3	1.16	0.56	44.5	1.800	1.15	57.8	2.37
0.10	15.4	1.18	0.57	44.8	1.810	1.20	58.5	2.41
0.11	16.6	1.20	0.58	45.1	1.820	1.25	59.2	2.45
0.12	17.8	1.21	0.59	45.4	1.830	1.30	59.9	2.49
0.13	18.8	1.23	0.60	45.8	1.840	1.35	60.5	2.53
0.14	19.9	1.24	0.61	46.0	1.850	1.40	61.0	2.56
0.15	21.0	1.26	0.62	46.4	1.862	1.45	61.6	2.60
0.16	21.9	1.28	0.63	46.7	1.873	1.50	62.2	2.64
0.17	22.8	1.29	0.64	47.0	1.885	1.55	62.7	2.68
0.18	23.7	1.31	0.65	47.3	1.898	1.60	63.2	2.72
0.19	24.6	1.32	0.66	47.6	1.910	1.65	63.7	2.76
0.20	25.5	1.34	0.67	47.8	1.920	1.70	64.2	2.79
0.21	26.3	1.35	0.68	48.1	1.930	1.75	64.6	2.83
0.22	27.1	1.37	0.69	48.4	1.940	1.80	65.1	2.86
0.23	27.8	1.38	0.70	48.7	1.950	1.85	65.5	2.90
0.24	28.6	1.40	0.71	49.0	1.960	1.90	65.9	2.93
0.25	29.3	1.41	0.72	49.2	1.970	1.95	66.3	2.97
0.26	30.0	1.43	0.73	49.5	1.980	2.00	66.7	3.00
0.27	30.7	1.44	0.74	49.8	1.990	2.05	67.0	3.03
0.28	31.3	1.45	0.75	50.0	2.000	2.10	67.4	3.06
0.29	31.9	1.47	0.76	50.2	2.010	2.15	67.8	3.10
0.30	32.6	1.48	0.77	50.5	2.020	2.20	68.1	3.13
0.31	33.2	1.49	0.78	50.7	2.030	2.25	68.4	3.16
0.32	33.8	1.51	0.79	51.0	2.040	2.30	68.7	3.20
0.33	34.4	1.52	0.80	51.2	2.050	2.35	69.0	3.23
0.34	35.0	1.53	0.81	51.4	2.060	2.40	69.3	3.26
0.35	35.5	1.55	0.82	51.6	2.070	2.45	69.6	3.29
0.36	36.0	1.56	0.83	51.8	2.080	2.50	69.9	3.32
0.37	36.5	1.57	0.84	52.1	2.090	2.55	70.2	3.35
0.38	37.0	1.58	0.85	52.4	2.100	2.60	70.4	3.38
0.39	37.5	1.60	0.86	52.6	2.110	2.65	70.7	3.41
0.40	38.0	1.61	0.87	52.8	2.120	2.70	70.9	3.44
0.41	38.5	1.62	0.88	53.0	2.130	2.75	71.2	3.47
0.42	39.0	1.63	0.89	53.2	2.140	2.80	71.5	3.50
0.43	39.4	1.65	0.90	53.4	2.150	2.85	71.7	3.53
0.44	39.8	1.66	0.91	53.6	2.160	2.90	71.9	3.56
0.45	40.2	1.67	0.92	53.8	2.170	2.95	72.1	3.58
0.46	40.7	1.68	0.93	54.0	2.178	3.00	72.2	3.60
0.47	41.1	1.69	0.94	54.2	2.185			

* Courtesy Dayton Rogers Manufacturing Company.

† How to use table: Divide height of shell by diameter; find corresponding ratio in column 1; per cent reduction is given in column 2 (use to determine number of reductions required); blank-draw-ratio is given in column 3; blank-draw ratio times shell diameter equals blank diameter approximately).

Work-hardening Tendencies of Stainless Steel

Because chromium-nickel stainless work hardens, it is necessary to use a lower press speed, say a conservative rate of 25 to 30 f.p.m. Recently a number of fabricators have increased speeds to as high as 50 f.p.m. by careful attention to die design, lubrication, and close annealing control. However, for average practice a lower speed will be safer and will prevent the metal from being drawn too rapidly into the die. Reductions as high as 50 to 55 per cent have been made under certain circumstances, but the normal drawing reduction in the initial draw is about 40 per cent. This varies with gage and diameter of blank. On 14 gage 18-8 stainless steel with a blank diameter of over 36 in. 30 to 35 per cent is a safe limit. Subsequent draws will be between 20 and 25 per cent, depending on size of blank and material being handled. Straight-chromium steel can be reduced about 20 to 25 per cent in the first operation. For extra deep-drawing qualities a hardness not exceeding 80 Rockwell B is desirable.

What Dies Are Suitable

Solid dies of the high-carbon high-chrome composition are suitable for drawing chromium-nickel steel. Chromium-nickel cast iron dies stand up well for severe reductions on fairly long runs. Tungsten-carbide dies have recently been tried for long-run drawing of smaller parts by several large fabricating companies, and good working characteristics and exceptionally long tool life have been reported. On larger parts, tungsten-carbide inserts are being used on draw rings; cost is high and breakage is possible. Cast iron tools are suitable for short-run work on the lower tensile stainless steels.

Hard cast bronze of 300 to 325 Brinell hardness is almost a standard draw-ring material with many companies. The centrifugally cast grade has longer life. Chromium-nickel cast iron draw rings are recommended by certain press manufacturers and fabricators for long-run drawing. Polishing of the draw ring in the direction of drawing is recommended, and a growing practice is to stone the draw ring on the radii. Improved finish and more pieces between grinds has resulted. At the first sign of metal pickup it is advisable to stone tool surfaces.

Preheating the dies to about 200° F. increases the ductility of straight-chromium steels and makes them more adaptable to deep-drawing operations.

Draw-ring radii should be four to six times the thickness of the steel (see Table 2). This avoids stretching the metal and allows it to flow more freely into the die, at the same time decreasing the rate of work hardening. Occasionally, because of the high elastic limit of stainless and design of the part, the final anneal may be followed by a restriking

TABLE 2.—DRAWING CLEARANCES AND RADII FOR STAINLESS STEELS

Metal thickness		Chromium-nickel			Straight chromium		
Gage No.	In.	Die clear-ance, in.	Die radius, in.*	Punch radius, in.†	Die clear-ance, in.	Die radius, in.*	Punch radius, in.†
30	0.0120	0.0144	0.0600	0.0360	0.0138	0.0480	0.0264
28	0.0149	0.0178	0.0745	0.0447	0.0171	0.0596	0.0328
26	0.0179	0.0215	0.0895	0.0537	0.0205	0.0646	0.0471
24	0.0230	0.0287	0.1195	0.0717	0.0280	0.0956	0.0526
22	0.0299	0.0359	0.1495	0.0897	0.0344	0.1196	0.0658
20	0.0418	0.0431	0.1795	0.1077	0.0413	0.1436	0.0790
18	0.0500	0.0600	0.2390	0.1434	0.0550	0.1913	0.1052
16	0.0598	0.0738	0.2990	0.1794	0.0688	0.2392	0.1316
14	0.0747	0.0896	0.3735	0.2241	0.0859	0.2988	0.1643
12	0.1046	0.1255	0.5230	0.3138	0.1202	0.4184	0.2301
10	0.1345	0.1614	0.6725	0.4035	0.1547	0.5420	0.2959
8	0.1644	0.1973	0.8220	0.4932	0.1891	0.6576	0.3617
6	0.1943	0.2332	0.9750	0.5820	0.2234	0.7772	0.4275
4	0.2242	0.2690	1.1210	0.6726	0.2578	0.8968	0.4932

* For first drawing operation.
† This dimension depends on design requirements.

operation. Provision for a self-centering punch and die prevents distortion and scoring of the work by eliminating side play and maintaining original clearances.

Failure to remove all lubricants thoroughly before annealing results in formation of a crusty scale. Lubricants may be removed by benzine, followed by suitable alkali cleaning solutions at boiling temperature. A high rate of evaporation is desirable. If an oil-soluble lubricant is used, cleaning may be done with a degreaser.

For a first operation, with a moderate draw, the punch diameter may be 60 per cent of the blank diameter. Following draws are made, after intermediate cleaning and annealing, with punches approximately 20 per cent smaller in diameter for each successive operation. Sequence of punch diameters will be determined more closely when all variables are accounted for. If distortion appears in the part after the final anneal, it may be necessary to reduce the severity of draws or add an additional one. Many fabricators report that they have made as many as three or four draws before giving an anneal. Shop variables will determine the frequency of anneals.

ANNEALING TEMPERATURES

In writing on the subject of stainless steel operations in press work, Peter Hallin, Engineering Division, Stafford Tool & Die, Inc., suggests

annealing temperatures between 1850 and 1900° F. as providing maximum ductility and resistance to corrosion in 18-8 type stainless steel. Minimum annealing scale leads to successful die operation and economical die life. Oxygen-bearing compounds should be removed from furnace atmospheres. Dissociated ammonia (cracked) is a good fuel. Refrigerant driers remove water vapor and give stock a bright anneal.

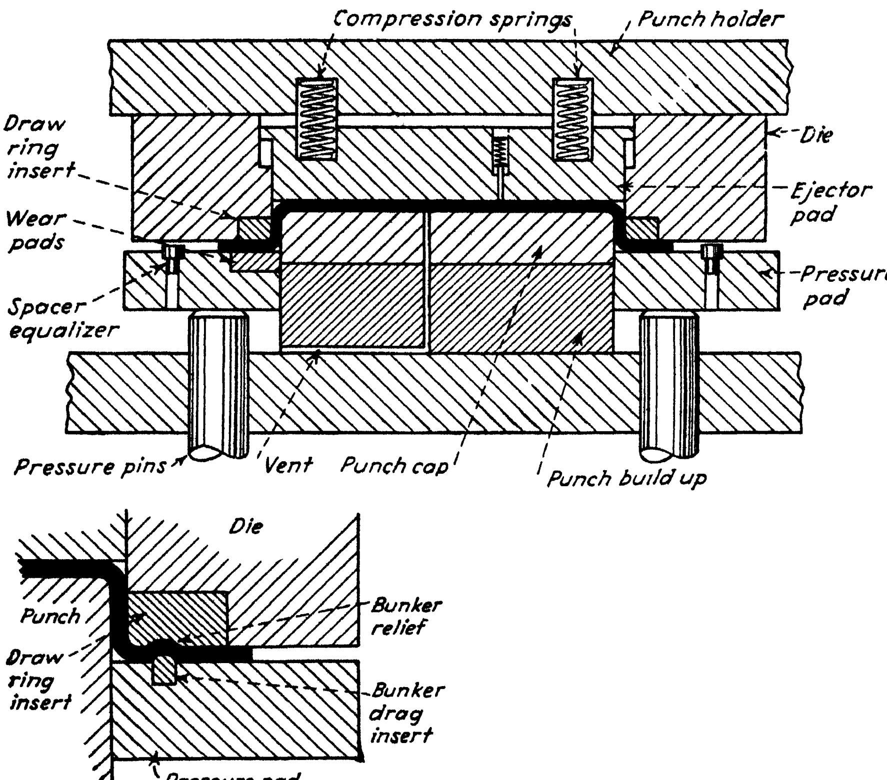


FIG. 73.—Shallow draw die for stainless steel. Lower enlarged section shows bunker-drag insert where more drag is needed between draw ring and pressure pad to eliminate wrinkling.

In regard to die design, he states that for stainless steel the die should be as heavy as one required for mild steel of approximately five gages greater stock thickness. It is stated that a good bronze for general use in drawing rings is aluminum bronze containing more than 7½ per cent and less than 11 per cent of aluminum. A recommended type, which can be heat-treated, contains 82 per cent copper, 9.5 per cent aluminum, 5 per cent nickel, 2.5 per cent iron, and 1 per cent manganese. It hardens at 1500 to 1600° F. by water quench and anneals at 700 to 1100° F. with a Rockwell B hardness of 105 to 106. An aluminum content of about

$13\frac{1}{2}$ per cent will give chisel hardness, but it is almost too brittle for practical purposes.

Machining operations on the aluminum bronze series require certain tool adaptations. A high spiral drill is most satisfactory, and the cutting edges should not be dubbed off. Spiral reamers having approximately 4 degrees rake work very well. An added rake on taps is desirable. Machining cuts should be heavy and uninterrupted as aluminum bronze work hardens if the cutting tool is allowed to ride the cut.

A typical shallow draw die is shown in Fig. 73. As indicated, the design of such a die for stainless steel may be simple, following conventional standards but with greatly increased ruggedness. Bunker drags are useful at points where more drag is needed between draw ring and pressure pad to eliminate wrinkles.

Drawing Compounds

Stainless steel requires drawing compounds of a much higher film strength than mild steels. Basically, drawing compounds have the action of a separating layer of film between the material being worked and the die parts. This film is difficult to maintain because of the toughness of stainless steel and its resistance to plastic deformation. Film strength, determined by basic ingredients and alkaline saponification of the fatty materials used, is the most important requirement in selecting drawing compounds. Sulphurized or chlorinated compounds have high film strength and are desirable in the presence of frictional heat set up by press action. Several commercial drawing compounds are available. Some of them must be kept hot and agitated after being mixed with water, and converted washing machines have been used with success to keep them in this state.

For light drawing operations, an oil mist blown in at the edge of the die has been found practical. A regular air-oil lubricating unit is attached to the press and a feeder tube run to the die perimeter, where suitable outlets cover sheet and die as the ram descends.

ALUMINUM DRAWING OPERATIONS[1]

Of the aluminum alloys generally suitable for drawing, three, designated by the Aluminum Company of America as 2S, 3S, and 52S, are called common, while two others, namely, 53S and 61S, are heat-treatable. When drawing *common* alloy sheet, annealed sheet is used for severe draws, while half-hard or even full-hard sheet may be suitable for the less severe draws. Alloy 53S is generally drawn from the annealed (0) or the quenched (W) temper and the shell later brought to the fully heat-treated

[1] **Abstract of report in *American Machinist* by L. J. Weber and J. T. Weinzierl, Aluminum Company of America.**

temper. Shells from quenched (W) temper sheet require aging at 320° F. or slightly higher, the time of heating varying with the temperature chosen. When sheet in the soft temper is used, the shell must be heat-treated at 960° F. and then aged. The W temper is used wherever possible to eliminate the need for heat-treating the drawn shells, which may be difficult to handle and which distort in quenching. During drawing, the metal strain hardens and changes from the annealed to the harder tempers with an increase in mechanical properties. It therefore becomes less workable and the reductions per draw in successive draws must be decreased. For deep-drawn cylindrical work in alloys 2S-0 and 3S-0 the reductions in diameter per draw should be as in Table 3.

TABLE 3.—REDUCTION IN DIAMETER FOR DEEP ALUMINUM SHELLS

Operation	Desired reduction	Permissible reduction
Blank D		
First draw (D_1)	40 (or less) D	42D
Second draw (D_2)	$20D_1$	$25D_1$
Third draw (D_3)	$05D_2$	$18D_2$
Fourth draw (D_4)	$05D_3$	$15D_3$

After the third draw, there is little change in hardness and the 15 per cent value in Table 2 is suitable for all succeeding draws. The values in the table may be varied but should not be exceeded appreciably. For harder alloys such as 52S they may have to be reduced as much as 10 per cent for the first draw and 5 per cent for succeeding draws.

The drawing tools should be so designed that the thickness of the metal is changed very little. This practice differs from that for brass and steel sheet, which may be reduced as much as 50 per cent, and it is often necessary to redesign tools used for such materials when they are to be used for drawing aluminum.

The radius on the die should be no less than four times and no more than 15 times the original thickness of the metal. The punch radius should be held to a minimum of four times the thickness. Too sharp a radius may cause fracture due to resistance in the flow of metal; if the radius is too large, wrinkling may occur in the side walls of the shell.

TYPES OF DIES USED

Cast iron tools have been widely used for a small number of pieces where tool costs must be kept at a minimum. Such tools are also well adapted for larger quantities where requirements of surface finish on the drawn parts are not exacting. While higher in cost a number of grades of alloy cast iron are sometimes used because they give better results.

On large production runs where the extra cost is justified, high-grade alloy tool steels have been found to give best results. They are also used for drawing shells from hard alloys and on work where scratches must be kept at a minimum. Oil-hardening steels are used usually so that the maximum hardness with minimum distortion is obtained during heat-treat-

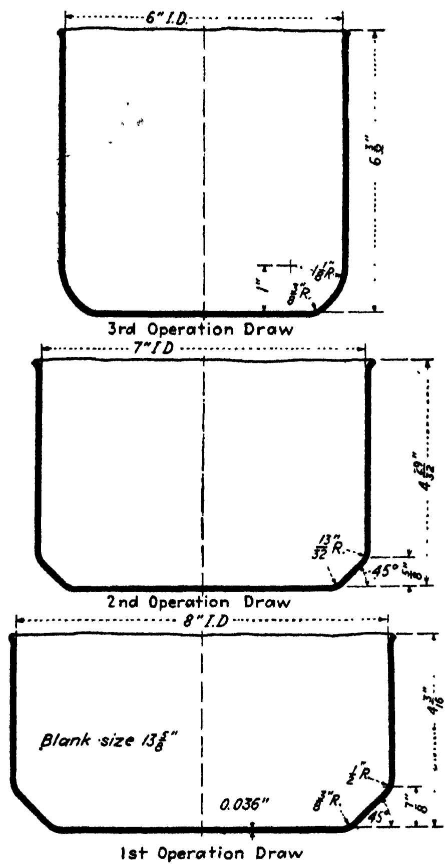


FIG. 74.—Sequence of operations in drawing cylindrical aluminum shells.

ment. Regular carbon steel with 0.6 to 1.10 per cent carbon is intermediate in cost and performance between cast iron and high-grade alloy steels.

In the case of rectangular shapes of shells, the greatest flow of metal is at the corners and this metal must be controlled to prevent wrinkles and fractures. Provision for this factor can be made by varying the draw radius. The sequence of operations in a drawn cylindrical cup is shown in Fig. 74. Table 4 gives the die dimensions for drawing rectangular shapes, and Table 5 gives die dimensions for cylindrical shapes.

Lubricant for drawing operations allows the blank to slip readily between blank holder and die and prevents stretching and galling while this movement takes place. Some of the oils that have proved suitable in this work are the following.

Severity of Draw	Lubricant Employed
Light	Light lubricating oil
Medium	Mixture of light oil and heavy lubricating oil
Severe	Heavy lubricating oil or 50% mutton tallow and 50% paraffin mixtures
Very severe	50% mutton tallow and 50% paraffin mixtures

TABLE 4.—DIE DIMENSIONS FOR DRAWING RECTANGULAR SHAPES

First draw	Add 2.2 times blank thickness to punch dimension
Second draw	Add 2.2 times blank thickness to punch dimension
Final draw	Add 2 times blank thickness to punch dimension

TABLE 5.—DIE DIMENSIONS FOR DRAWING CYLINDRICAL SHAPES

First draw	Punch diameter plus 2.2 times thickness of blank
Second draw	Punch diameter plus 2.3 times thickness of blank
Third and succeeding draws	Punch diameter plus 2.4 times thickness of blank
Final draw of tapered shells	Punch diameter plus 2 times thickness of blank

DEEP DRAWING OF MONEL, NICKEL, AND INCONEL

Monel, nickel, and Inconel deep-drawing quality sheets and strip may be drawn into any shape feasible with deep-drawing steel. Few commercial operations require changes or variations in die equipment designed for drawing steel or brass. In a few cases calling for severe drawing and extreme accuracy, modifications must be made.

Gray and cast semi-steel dies are satisfactory for short runs of a few hundred pieces. Hard bronzes, heat-treated nickel-chromium cast iron, chromium-plated hardened steel, and, for very small work, tungsten carbide are recommended for dies used on large production runs. High-nickel materials have a tendency to gall against carbon-steel dies, and they should not be used. Dies and punches must be kept well polished. Beef tallow and castor oil are good lubricants; so also are water-soluble or oil-soluble lubricants compounded from these two substances and containing fillers. White lead and graphite, also sulphur-bearing lubricants, are excellent but must not be used if the parts are to be annealed after drawing. All lubricants should be removed completely before annealing. When drawn shells reach a Rockwell hardness of B 95, or over, annealing usually is necessary.

Monel and nickel require only slightly more die clearance than steel. The difference is so small that little difficulty ordinarily is experienced when drawing over dies originally laid out for steel. For ordinary deep drawing of light gage cylindrical shells, an over-all clearance equal to about 40 to 50 per cent of the thickness of the material is ample. With

heavy gage sheets, the over-all clearance generally is about equal to the thickness of the stock. The curved surface over which the material is drawn should have radii as great as possible without developing wrinkles in the shell. Draw-ring and punch nose radii for light gage cylindrical shells are usually from 5 to 12 times the thickness of the stock. Corner-edge radius for a rectangular shell should be from 4 to 10 times stock thickness.

On a double action press with pressure ring, a well-balanced series of reductions for light gage cylindrical shells, with no "ironing" of the side walls, would be approximately 30 to 40 per cent in the first, or cupping,

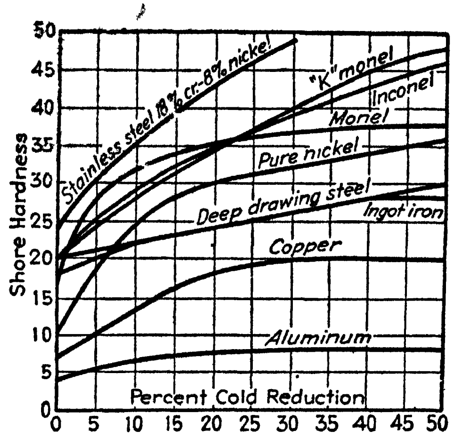


FIG. 75.—Increase in hardness of metals and alloys with cold working; starting with annealed material.

operations, and 15 to 25 per cent on redrawing operations. Single action redraws, without pressure rings, rarely exceed 20 per cent for light gages; however, with very slight diameter reductions (less than 5 per cent), up to 30 per cent reduction in wall thickness can be obtained. Experience has shown that the depth of rectangular draws should be limited to from two to four times the corner radius. The term "reduction," as it is used above, refers to reduction of shell or blank diameter, and not to the area reduction.

Figure 75 shows increase in Shore hardness of various metals and alloys, including Monel, nickel, Inconel, and others, with cold working, starting with annealed material.

MAGNESIUM-BASE ALLOY DRAWING AND OTHER OPERATIONS[1]

The preceding pages have covered certain details relating to handling of brass, aluminum, steel, and other materials in drawing and other press operations. In concluding this chapter a few particulars are given concerning working of magnesium-base alloy sheets.

Magnesium-base alloys lend themselves to such forming operations

[1] From Report in *American Machinist*.

as bending, drawing, pressing and spinning. These alloys harden rapidly when cold-worked, and cold forming around small radii may lead to trouble. At elevated temperatures most of the alloys may be formed easily into intricate shapes. Hot forming is best done between 500 and 700°F., this temperature should be checked with a surface thermometer. Temperatures as low as 400°F. may be employed for moderate forming operations. Heating to above 750°F. lowers the mechanical properties of the alloys slightly. Above 800°F. the alloys become hot-short and grain growth is promoted. Forming tools should be clean, smooth, and well lubricated. Lard oil frequently is used, since it stands the heat well and can be removed easily with alkaline cleaners.

Blanking and shearing of thin sheet are accomplished as with other metals. With ordinary tools, blanked or sheared edges more than 0.065

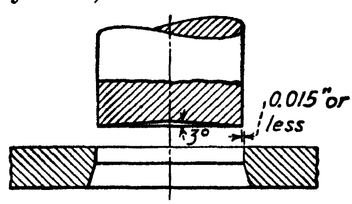


FIG. 76.—Clearance between punch and die for magnesium must be held to a minimum. A slight rake often helps the punch shear a smooth edge.

in. thick tend to have a flaky structure. Special designs in punches and shear often will permit smooth cuts in stock up to several times this thickness. The use of an included angle of 60 degrees for the upper blade of power shears will permit cuts in plate up to ½ in. thick. As little clearance as possible should be used. Edge roughness should be dressed off the sheet to improve forming and fatigue characteristics, as well as paint adhesion.

BLANKING AND PUNCHING

When blanking or punching sheet, or flat and thin extruded stock, clearance between punch and die should be held to the minimum permitted by the accuracy of the press. A clearance of 0.015 in. or less (Fig. 76) is recommended. Smooth edges on sheet thicker than 0.065 in. can be obtained by warming the sheet to 500 to 600°F. before blanking. A slight rake (about 3 degrees) on the punch also will improve the sheared surface. If heating is necessary in this and subsequent operations, dimensional changes due to expansion during heating, and subsequent contraction, must be considered by the part and tool designers in order that the piece may be of proper size.

Bending and forming. Sharp corners and burrs must be removed from the edges of the sheet near the bend line if short-radius bends are to be made. Bend lines should not be scribed or prick-punched, for such

marks may lead to fatigue cracks. Minimum cold-bending radius for sheet stock varies with the alloy, temper, thickness, and rate of deformation. Type of equipment used and relation of axis of bend to direction of sheet rolling also influence results.

Annealed sheet stock has the best cold-forming properties. With such stock a bend radius of four times stock thickness usually is permissible under shop conditions. An actual trial should be made before determining minimum permissible radii. Hard rolled sheet can be given only a limited amount of cold bending. Such material usually can be bent around a radius of five to ten times stock thickness, the required radius tending to increase directly with thickness and amount of cold working.

Sharper bends can be made by hot bending; radii of 2 to 2½ times sheet thickness being obtained in the shop regardless of alloy or temper. In either hot or cold bending a slow rate of deformation will give best results. Heating for hot forming changes properties of hard-rolled sheet but does not change room-temperature properties of annealed sheet. Time of heating should be just enough to heat the sheet thoroughly. Speed of cooling in thin air and the low heat capacity of the metal require rapid handling and the use of preheated tools.

Sheets to be hot-formed may be heated with a blow torch, in an oven, or by dipping for several minutes in a hot oil bath. Use of ovens is recommended as the temperature then can be controlled accurately. The heating of bending dies and the performance of the operation in a stream of hot air are two means frequently used to improve the bending of magnesium alloy parts. Local heating with a torch is difficult to control, but sometimes is necessary.

Pressing and drawing. Although each case must be considered individually, draws and pressings of medium depth can be made successfully. Best results are obtained by heating the dies. Magnesium, aluminum, or steel dies should be used. Dies of magnesium have the advantage of expanding at the same rate as the sheet being worked. Design of the dies follows closely that used for other metals. Where the forming operation is not severe and the work can be done cold, it sometimes is possible to adapt dies developed for other metals. It usually is necessary, however, to arrange for heating the dies. Ring-type gas burners have been used for this purpose. Sometimes smaller dies can be heated electrically or with hand torches. When forming intricate shapes, it often is advantageous to combine simple forming with welding. Production-forming operations are carried out in (1) cast dies forced together with a jack; (2) drop hammers, ordinarily using heated zinc or lead forms; (3) friction presses using the same forms; and (4) hydraulic presses using lubricated iron or steel dies. Tools should be clean, smooth, and well lubricated. Lard oil often is used.

Spinning. Only a small amount of spinning can be done cold. If the work is kept hot during the operation on the spinning lathe, magnesium alloys can be spun to shape without difficulty. Heat is applied by torch while the sheet is rotating. Depending on the severity of the deformation, a speed of 300 to 450 r.p.m. is recommended when spinning disks 15 to 25 in. in diameter. Laundry soap or a mixture of two parts tallow and one part paraffin is used to lubricate the work. The edge of the sheet should be filed clean before starting to reduce the risk of edge cracks. Wooden chucks are satisfactory if only a few pieces are to be made. Cast aluminum or magnesium chucks last longer.

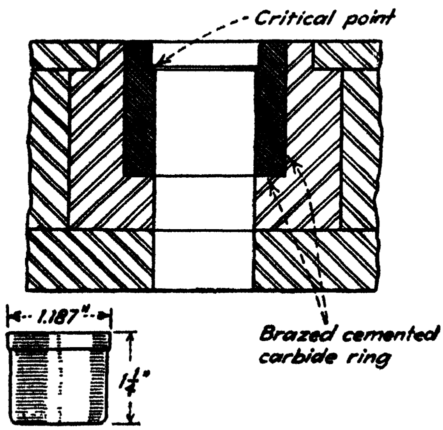


FIG. 77.—Combination draw and form die with carbide draw ring, for refrigerator muffler. As many as 700,000 parts made between repolishing operations as against 60,000 parts with high-carbon, high-chrome tool-steel inserts, between dressings.

CARBIDE DRAWING DIES

Carbides found considerable application in the construction of dies for drawing and tapering both brass and steel cartridge cases during the Second World War. Today, carbide draw dies are being used with considerable economy in tool cost per piece produced for the manufacture of small cylinders for storing gases under high pressures, kitchen utensils, containers for dry cells, flashlight cases, food and beverage cans, headlight reflectors, hub caps, cigarette cases and cosmetic containers, camera parts, and refrigerator parts.

Material being drawn includes carbon and alloy steels, brass, copper, aluminum, magnesium, gold, and silver. Sylvania Electric Products has used carbide draw dies on nickel and reports they do not build up with nickel as do steel dies. This reduces down time for die repairs.

Before the war, the largest carbide die for deep-drawing sheet metal had an inside diameter of about 4 in. Today, carbide deep-drawing dies as large as 13 to 15 in. I.D. are in production service. The General Electric Company has obtained excellent results from the use of cemented-carbide inserts in high-production draw dies, especially where part design and tolerances are critical. In the production of the refrigerator muffler shell, Fig. 77, for example, the maximum production obtained between die repolishing operations at the critical point was about 60,000 parts when the best grade of high-carbon high-chrome tool steel was used.

Referring again to the Brosher report[1] on carbide dies it is stated that this part is made from 0.030 in. thick deep-drawing steel, and both copper-plated and unplated stock was used without affecting results materially. However, when carbide draw rings were used in the die, approximately 700,000 parts were run before the die required polishing. This was done with a tool-steel punch, using standard unplated deep-drawing steel stock. Similarly, other tools produced approximately 500,000 refrigerator shells from 0.060-in.-thick deep-drawing steel between die polishing operations. Before the carbide draw ring was inserted in the die, about 30,000 parts were produced per die polish, and the die had a total life of only 160,000 to 200,000 parts. Extremely close tolerances must be held on this part.

Less Finishing on Parts

The DeLaval Separator Company advises that smooth parts without scratches are being produced in their carbide draw dies, and therefore less

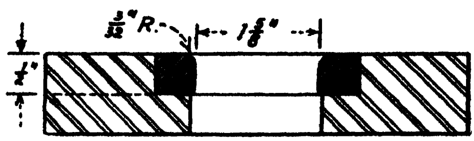


Fig. 78.—Used for drawing a cup from 0.050-in.-thick stainless steel, this carbide draw ring finished an order for 15,000 parts without requiring any maintenance. A tool-steel die for the same part lasted for only 800 pieces before wearing beyond allowable limits, while a nickel-iron die made only 2,000 pieces before failure.

time is required for finishing operations. Die life is longer because of reduced wear on the dies and reduced polishing.

While the initial cost of such dies usually is three to four times higher than that of all-steel dies, the company expects to save the extra cost within a few months. Officials point out it is important to design the dies with the proper thickness of carbide inserts and with sufficient steel backing to withstand the strains and shocks to which they will be subjected. Figure 78 shows the cross section of a ring for a draw die having a carbide insert for drawing a part similar in shape to that shown in Fig. 77, but with smaller dimensions and drawn from 0.050-in.-thick stainless steel sheet.

With this die ring, a total of 15,000 parts have been drawn to date without the die requiring any maintenance and without noticeable change in the condition of the die surfaces. A tool-steel die for the same part produced 800 pieces before wearing oversize, and in that time required 3 hr. of attention from die-maintenance men. A nickel-iron die lasted for 2,000 pieces before wearing oversize and required 1.5 hr. for tool maintenance.

[1] *American Machinist*, Sept. 12, 1946.

Compacting dies for powder-metal parts must have sufficient hardness to resist wear, and must be strong enough to withstand high pressures. Forming dies having cemented-carbide liners are maintaining hole sizes 25 to 50 times longer than is possible with steel dies, according to service reports. High polish on the liners helps reduce the friction set up during the pressing or "tableting" operation.

Products now being compressed in such dies include oilless bearings, gears, cams, carbide blanks, diamond wheels, refractory wheels, carbon products, magnets, sparkplugs, filters, and bushings. Types of materials

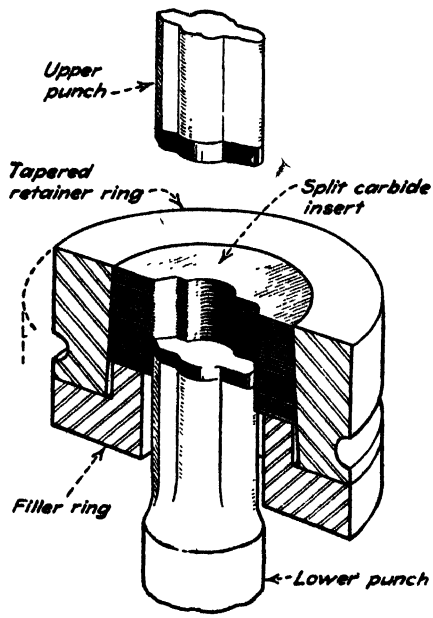


FIG. 79.—Carbide compacting molds last well even when working with highly abrasive ceramic compounds. Usually split dies are necessary for such materials.

being compressed include powder metals, porcelain, and clay. The General Electric Company is using cemented carbides to advantage in making molds for compacting ceramic materials. The compounds being molded are extremely abrasive, and tools made of the best high-carbon high-chrome tool steels were not satisfactory because of high maintenance cost and frequent interruptions in production.

To make use of cemented carbides in these compacting molds, it has been necessary to resort to a complicated split die design, Fig. 79. However, excellent results have been obtained and production has gone up from as low as 700 parts with tool-steel molds to as high as 100,000 parts with cemented-carbide inserts in the molds, before mold repairs are necessary.

Carbide-die Servicing Operations

It is recommended by authorities that where a concern is a large user of carbide dies it should be prepared to do servicing in its own plant; otherwise with the work done outside the plant there is a tendency to run dies longer on the job than is desirable between servicing operations. This results in less satisfactory performance from the point of both die life and continuous production.

According to Earl Glen of Carboloy Company, Inc., a reason for this is the characteristic of all carbide materials. Thus a shell case when it enters the mouth of a die presents a sharp edge at the outside diameter or at the point where it first comes in contact with the approach angle in the die. This is clearly shown in the sketch, Fig. 80. In time a fine ring is formed at this point of contact, as indicated in Fig. 81, and upon appear-

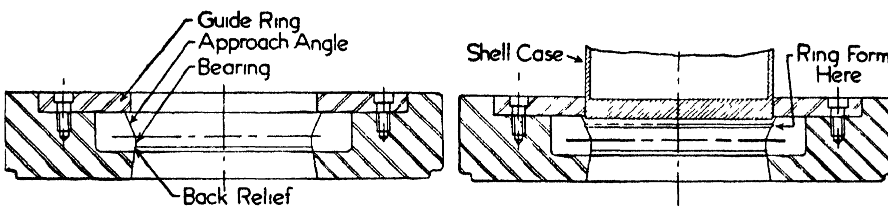


Fig. 80. Fig. 81.

Figs. 80–81.—Sections of drawing die.

ance of the ring the die should be repolished to remove the ring. Otherwise particles of carbide will gradually begin to break out, resulting in increase in die wear at this point.

The authority quoted continues pointing out that the length of time the average die will operate before this ring begins to form varies with the individual installation and also depends to a great extent on the effectiveness with which the case and the die are lubricated. From this standpoint it is highly important to see that the lubricant is carried through the die by the shell case. The most effective means of producing this result is to oxidize the shell case or provide it between draws with a thin rust coating to which the lubricant will adhere. As to the lubricants themselves, a great variety of different types are currently being used, and no definite conclusions have been reached as to the most effective type for any given installation.

It is a good practice in drawing shell cases with carbide dies to establish a definite period at the end of which the dies should be removed for polishing. No exact time interval can be given, however, as some companies are able to run three or four days before polishing, while others repolish their dies every 8 hours. Best practice is to watch the operation fairly carefully at the outset and determine the approximate period of time required before the the ring begins to form.

To remove the light rings, the major requirement so far as equipment is concerned is the provision of a lathe and a flexible shaft or similar type of hand grinder. To remove the rings, a brass rod is placed in the flexible shaft or hand grinder, and with this the ring is removed and the surface smoothed out, using a No. 3 diamond powder. The surface is then polished with a felt wheel in the flexible shaft or hand grinder using No. 5 diamond powder.

In servicing carbide dies, it is important that any pickup on the bearing surface of the die be carefully removed. This is particularly true on the final draw die. If pickup is removed with a stone, emery cloth, etc., the die can easily be worn out faster in polishing it than in normal service. The tolerance on the bearing diameter of the final draw die is only 0.002 in., and once this diameter has been exceeded, the die (unless it can be recut to a larger draw) will have to be scrapped. On preliminary and intermediate drawing operations, this is not quite as critical, but nevertheless here also it is quite possible to wear the die out faster in servicing it than it does in actual use. Best practice is to cut any pickup off carefully with a sharp scraper and then polish the surface.

Standardization of Carbide Die Sizes

As the result of cooperative study with the Ordnance Division and shell-case producers, it has been possible to standardize carbide dies so that a single basic die size can be used for all drawing operations from the first to the final draw on any given type of shell case. As a matter of fact, it is possible to start with a die for the final draw of a 37-mm. shell case, gradually recut it as the die wears to the first draw on the 37-mm., and when worn out for this operation, recut it to handle successive draws on 40-mm. shell case. Similarly, a single die size can be used for 3-in. antiaircraft and 105-mm. shell cases.

Die-recutting Method

For recutting of dies, an internal grinder is required. With this, and using a 100-grit diamond wheel, the bearing is first resized to within 0.001 in. of desired dimension. The approach angle and radii are then reworked, using the same wheel.

The wheel is now removed and a steel lap inserted in its place, and the die is lapped to size, using a diamond powder.

Final polishing is with a buffing wheel, using a fine diamond powder which should always be mixed with olive oil. The buffing wheel should be used on a grinder or flexible shaft with the die mounted in the internal grinder.

In recutting, it is also important to reestablish the back relief angle to the correct specification.

CHAPTER XII

COMBINATION DIES AND COMPOUND DIES

Combination dies are frequently called compound tools and are actually in form similar to such dies. It has been customary, however, in many shops to draw a distinction between compound and combination dies in that the latter take the form of a combined tool for blanking and

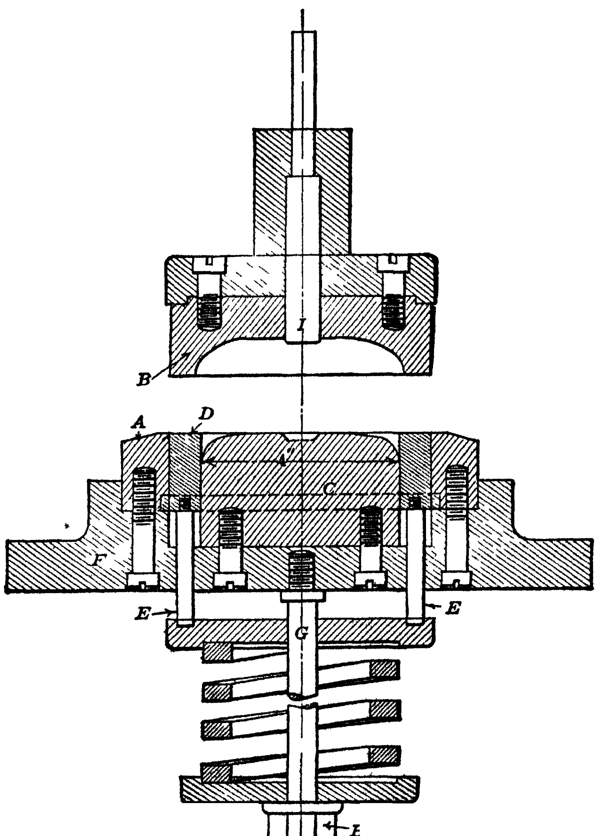


Fig. 82.—Section through combination die.

drawing or blanking and forming a piece, thus combining in the one tool a *cutting* operation with a *bending or drawing* operation, while the compound die usually is considered as a cutting tool wholly in that its blanking and piercing work is entirely a cutting process.

In recent years, however, many shops have become accustomed to applying the term compound die to any tool of the type where two operations are accomplished simultaneously with the dies built around the same common center line, as distinct from the progressive, or multi-stage, die.

Combination dies, in their usual form, are adapted for performing in a single action press the operations of cutting a blank, drawing a shell, forming the end or edge, beading, etc., and sometimes a piercing operation is included. The work is accomplished at a single stroke of the press, the tools all being located about a common vertical center line as with the compound dies described in Chapter VI. The dies carry their own pressure pads, drawing rings, and knock-outs and are set up in the press the same as a simple drawing die.

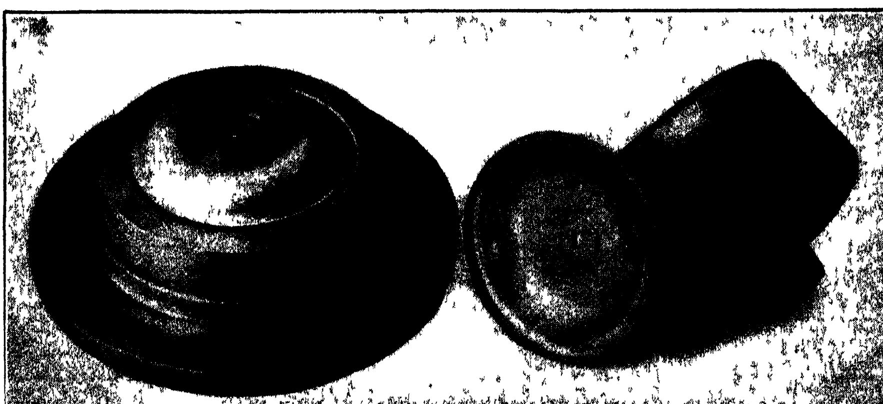


FIG. 83.—The forming dies.

A typical construction is shown in Fig. 82 herewith. These combination tools are for blanking, drawing, and forming the cover which in finished condition is shown in Fig. 83. The sketch, Fig. 82, shows the parts clearly. The blanking die edge is at A, the blanking punch at B. The draw post is at C, the draw ring at D. This rests upon a set of pressure pins E which extend down through the die shoe E to the pressure device G, which is fitted with a heavy spring that is regulated by nut H to apply the necessary pressure to the work held between D and B when the blanks are being drawn, to prevent wrinkling.

The blanking die, the pressure ring, and the blanking punch are of tool steel, hardened. The knock-out pin I which also indents the top of the cover is likewise of tool steel. The punch holder and die shoe are cast iron. The pressure pins E are drill rod. The plates or washers for confining the pressure spring are of machine steel.

The forming of the flange around the edge is attended to in the second operation dies, Fig. 83. A detail of the die arrangement is seen in the partial section, Fig. 84. Here the central member J of the lower die is adapted to be lifted by the pressure pins K to eject the work after the punch has started upward.

Pressure Springs and Pins

The number of pressure pins used about a die of the combination type varies with the size and form of the work. It may be that three will answer and it may be necessary to use four or more. The pressure device under the die shoe is equipped with the weight of spring necessary for accomplishing the work of controlling the pressure pad to give the desired tension to the material being drawn. In some instances the spring used must be of very heavy section. Rubber is often used instead of a coiled spring for this purpose, and some shops use it almost exclusively.

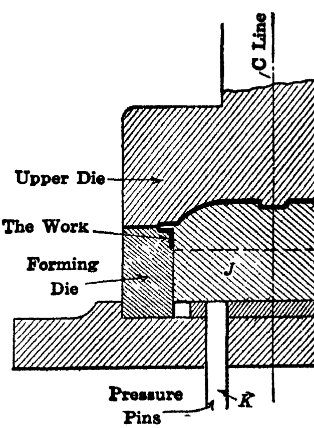


FIG. 84.—Partial view of the forming die.

Where many dies of this order are in service it is customary to make up a number of these pressure devices and have them used interchangeably throughout a series of dies where fairly uniform conditions exist as to pressures required. Both the coiled spring and the rubber buffer types admit of considerable variation in the degree of pressure they transmit, through the medium of the adjustment possible by the nut on the threaded supporting stud. But often the range of work is such that a wide difference is required in the drawing pressures for different dies and several spring attachments with corresponding range in their working capacities are desirable, if not absolutely necessary.

A Taper Shell Operation

In Fig. 85 a tapered steel shell is shown which is made in three operations. The first is in the combination die, Fig. 86. Here the blank is cut and drawn to the cylindrical form shown in the detail with dimensions of $2\frac{1}{4}$ in. diameter by $1\frac{1}{4}$ in. deep. The blanking die is at A, the blanking punch at B. The metal is held by spring pressure between the upper face of spring drawing ring or pressure pad C and the lower face of the drawing die at D, while the cup is drawn down over the drawing post E. The spring F is adjusted by the nut below to put sufficient tension on the blank so that it will not wrinkle as it is pulled down from between

faces C and D. On the up-stroke, the ring C strips the work from the drawing post E and the knock-out G clears the drawing die D. The

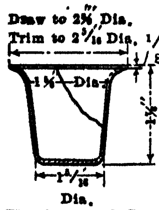


FIG. 85

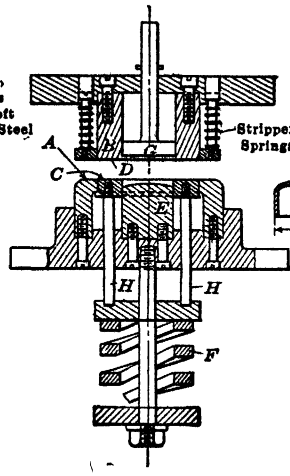


FIG. 86

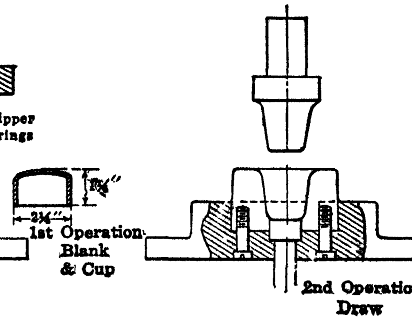


FIG. 87

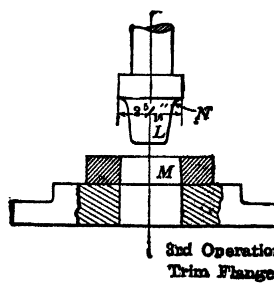


FIG. 89

FIGS. 85–87, 89.—Dies for drawing and trimming taper shell.

pressure of the spring F is, of course, transmitted to the drawing ring C by the pins H.

FIG. 88.—Dies for drawing a taper shell.

The die and punch are of tool steel hardened, and the pressure pins are of drill rod. The die shoe is cast iron and the punch holder is a machine steel plate.

The second operation tools for tapering the shell are shown in Figs. 87 and 88. In the latter view a shell tapered to form is seen in the fore-

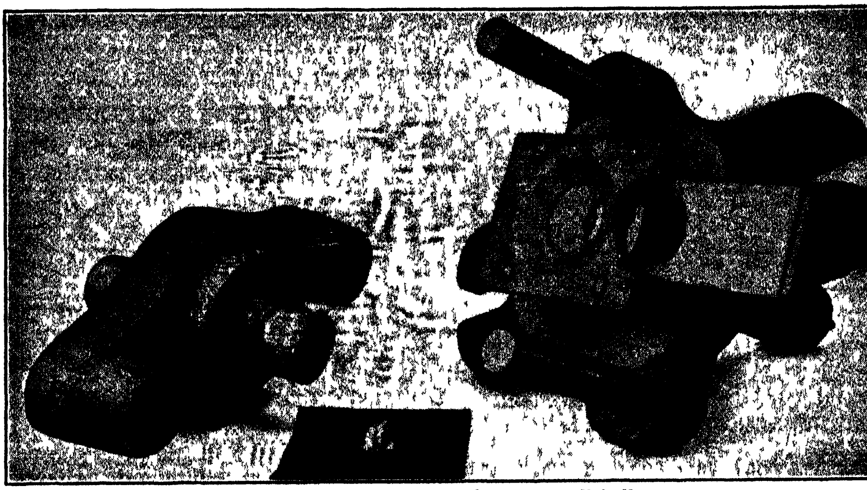


FIG. 90—Tools for making a small bell.

ground. These tools require little explanation. The knock-out in this case is in the bottom of the die and its head forms the lower portion of the die proper. This set of tapering tools produces a flange that is about

FIG. 91.—Tools for making a small bell.

$\frac{1}{16}$ in. larger than required, leaving ample stock for trimming in the dies in Fig. 89. These latter dies are simply a piloted punch *L* to center the work and an open die *M* to trim the size desired for the flange. The

trimming edge of the punch at N is given less clearance for the corresponding edge of the die than would be allowed for a blanking punch of the same diameter, on this thickness of stock, to prevent possibility of the narrow edge of the flange dragging into the die.

Tools for a Hemispherical Cup

The tools in Figs. 90 and 91 are for blanking and drawing up the German silver bell seen in detail in Fig. 92. This is $\frac{7}{8}$ in. outside diameter and has a slightly flattened top. It is made of stock $\frac{1}{32}$ in. thick.

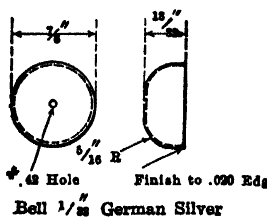


Fig. 92.—Detail of bell.

The two photographic views have been included to show more clearly the special slide for carrying the blank material into the dies. These bells are blanked out of slugs punched out in a piercing operation in making another larger piece. They are therefore fed into this die by a hand-operated slide having a nest the size of the slug and a definite travel back and forth to receive the slug conveniently and when pushed forward

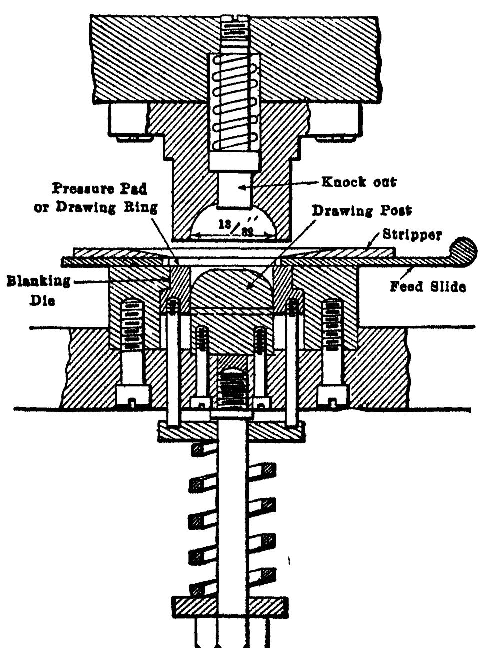


Fig. 93.—Construction of bell tools.

to center it over the die. The central position of the slide is shown by Fig. 91; the preceding photograph shows the slide withdrawn for another piece of blank material.

The slugs from which the bells are blanked in these dies are enough larger than the blanking punch to leave a fair margin to prevent the rim of material dragging into the drawing die. The stripper over the slide and stock is beveled out for a half inch in all directions and the pressure pad or drawing ring comes flush with the cutting edge of the blanking die when the punch is up. The general features of the tools are well shown by the photographs and the sectional drawing, Fig. 93, and aside from the foregoing reference to the method of carrying the work into the dies little description seems necessary.

MAKING A SHALLOW CIRCULAR HOUSING

The press tools in Fig. 94 are for making a circular case which is used as a pawl housing on a coin register. The detail of the piece is shown by

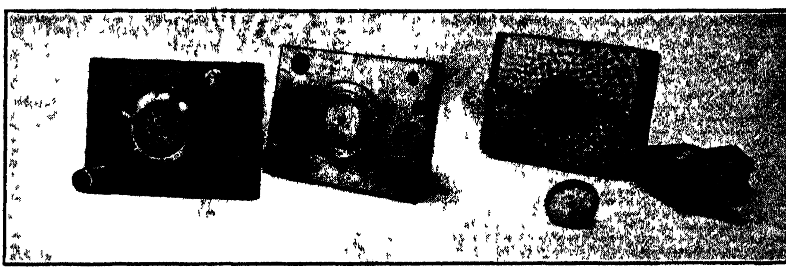


FIG. 94.—Tools for a shallow housing.

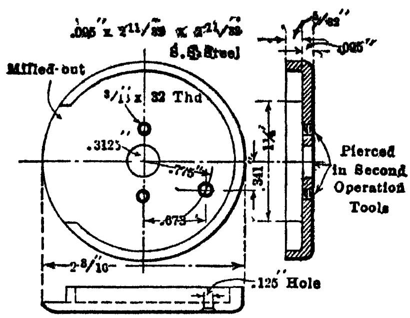
the sketch, Fig. 95. From this latter view it will be gathered that the shallow case or housing is made of $\frac{3}{32}$-in. soft steel which is drawn up to a cup $\frac{5}{32}$ in. deep inside, the outside diameter being $2\frac{3}{16}$ in. The blanking and drawing are accomplished in the combination tools, Fig. 96; the piercing of four holes seen in the detail is done in a second operation with the tools sectioned in Fig. 97.

The different elements of the dies, Fig. 96, that is, the cutting edge for the blank, the blanking punch, the drawing post, the pressure ring, the knock-out for the punch, are all designated by name. All are of tool steel hardened. The pressure pins and pressure spring underneath are also indicated by their respective names and the entire construction will be clear upon inspection of the sectional view.

Owing to the fact that the shell is very shallow in proportion to the diameter and the thickness of the stock, the cutting punch is necessarily quite thin in its side walls, and for that reason it is made relatively short inside to give as much strength as possible. Inside this punch is carried the upper knock-out which has a positive action upon striking the fixed stop on the press guides. The lower ejector is the same pressure ring that holds the material to the face of the drawing die to prevent wrinkling when the latter descends over the drawing post in the lower die.

This set of tools like the second operation set is fitted with guide pins similar to the bell tools in preceding illustrations.

The second operation tools, Fig. 97, pierce the central hole in the cup and also three other smaller holes spaced from the center in accordance



FINISHED WORK AFTER MILLING

Fig. 95

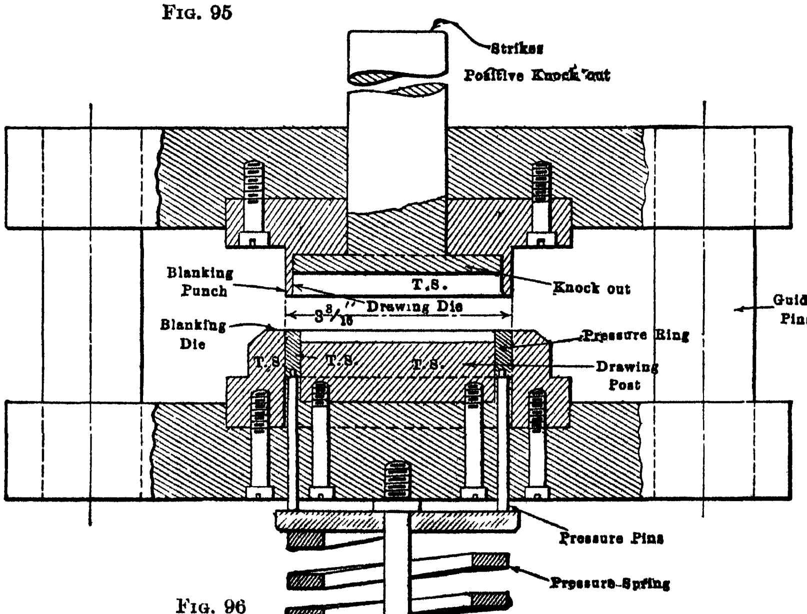


Fig. 96

Figs. 95–96.—Dies for first operation on pawl housing.

with the detail, Fig. 95. The piercing tools are fitted with a steel plate for the four punches as indicated and the punch holder carries a knock-out device for operating the stripper which is made a close fit for the several piercing punches. The die is recessed out to give a depth of ½ in. for the die top. The work locates over the top of the die which is ground to 2 in. diameter to suit the inside of the drawn piece.

The gap at one side of the work is cut out afterward in a milling operation.

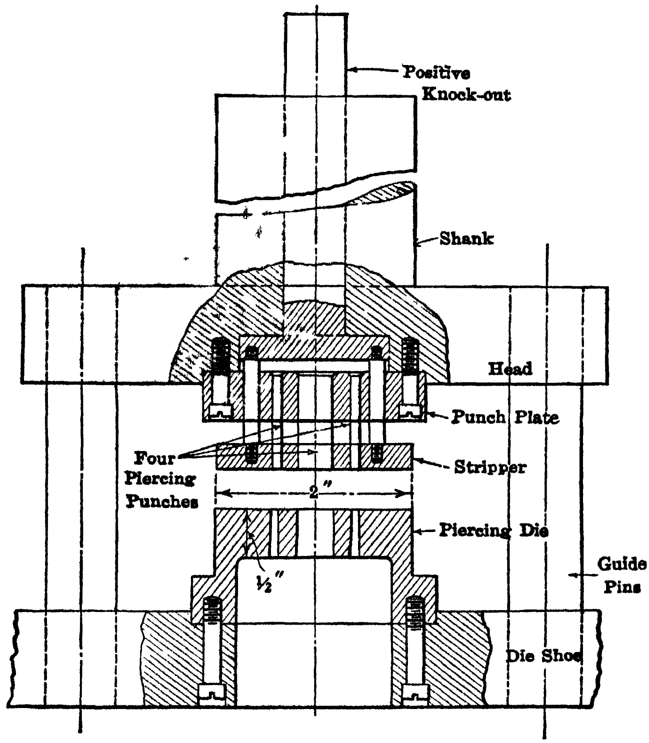


FIG. 97.—The piercing tools.

PIERCING TOOLS COMBINED WITH BLANKING AND DRAWING DIES

Oftentimes the operation of piercing is combined in tools of this class with the blanking and drawing or forming of the piece. A case of this kind is illustrated by Fig. 98, where a $\frac{3}{32}$-in. cap is shown as drawn and pierced with the tools in Fig. 99.

The cap is $2\frac{5}{8}$ in. inside diameter and $\frac{5}{8}$ in. deep. It is a gear shifting lever tower cap for automobiles, and has three small holes spaced near the rim and a larger hole through the center. The dies blank, draw, and pierce in a single action press.

The die is constructed as follows: The blanking and forming punch *A* which is of tool steel, hardened and ground, is fastened to the cast iron punch holder *B*. The blanking die *C* is of tool steel hardened and ground and seated in the cast iron base *D*. The piercing and forming die *F* is also seated in the base. The piercing punches *G* are shouldered to resist the force required for piercing, and are held in place by headless set screws.

The stripper *H*, which strips the scrap from the blanking punch, is suspended from the punch holder by six special screws *I*, which also serve as retainers for the stripper springs.

A rule that has been used successfully for the calculation of the stripping pressure required is to take this at approximately 7 per cent of the

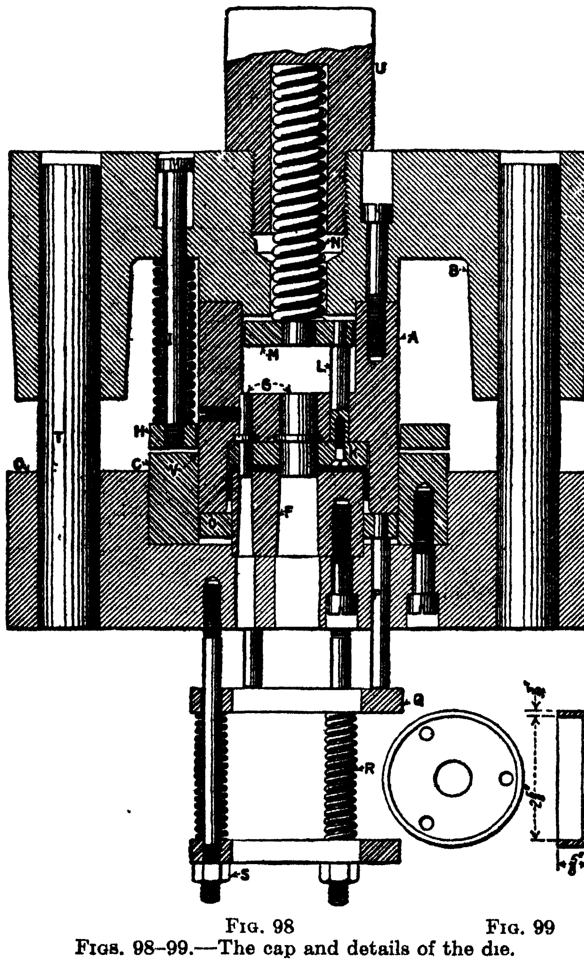


Fig. 98 Fig. 99

Figs. 98–99.—The cap and details of the die.

blanking pressure. The upper knock-out *K* is held in alinement with the punches by the three pins *L*, abutting against the disk *Q*, which transmits the spring pressure from the three springs *R* to the blank holder. The spring tension is adjusted by the nuts *S*. The guide pins *T*, which are of different diameters to prevent missetting of the die, are a press fit in the base and a sliding fit in the punch holder. The shank *U* is fastened in the ram of the press.

The operation of the die is as follows: The blank is cut from the strip by the punch A at the point marked V, and is held under tension between the punch A and the blank holder O. The punch A continues down, forming the cup around the die F. The punches G then pierce the holes; the knock-out K serves as a bumper, flattening the face of the cap. On the return stroke, the scrap is stripped from the punch A by the stripper H. The cup is pushed up flush with the blanking surface V by the stripper O. The knock-out K ejects the cap from the punch. It is essential to secure an even edge on the cap. No trimming is required with this type of die.

FIG 100.—Tools for drawing and piercing outlet box.

The tools in Figs. 100 and 101 are for drawing and forming an octagonal outlet box for electric wiring connections, the box being made of 14-gage steel in the shape shown by the sketch, Fig. 102 The box is about 3½ in. across, and is 1½ in. deep. There are five outlets punched in the face with the slugs punched practically through the metal to allow for ready knocking out with the electrician's hammer and screw driver, the opening slug or disk being held slightly at one edge by a ⅛-in. section of the metal which is not cut through with the punch. There are also four similar disks punched through the four walls in a later operation to allow for knocking out when required. There are six holes ¼ in. diameter pierced through the bottom of the box, all as indicated by the sketch. The two ears at the opposite edges in the sketch are formed in a following operation when the edges of the box are trimmed and the ears pierced. Following the trimming, the ears are bent over at right angles as seen in another set of dies, see Figs. 1 to 4, Chapter XVI.

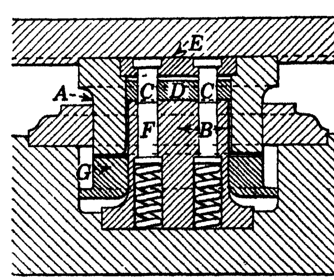


FIG. 101.—Section through dies in Fig. 100.

With reference now to Figs. 100 and 101, the arrangement of the drawing dies is shown clearly. The sectional view, Fig. 101, gives enough detail to make the construction clear, although some items, such as small piercing punches, holding screws, etc., are omitted in the drawing. Here it will be seen the upper punch *A*, which does the blanking, also serves as the drawing die, the drawing punch *B* having a seat in the die shoe below. The punches for breaking out the five openings in the face of the box are at *C*. These are housed in a plate let into the top of the blanking punch *A*. The disk *D*, through which the punches pass, serves as a stripper, as it is operated from the positive knock-out on the press when the ram ascends and thus clears the work from the lower ends of punches *C*, *C*, and ejects it from the inside of drawing die *A*. The small piercing punches for perforating the six $\frac{1}{4}$-in. holes are similarly located in plate *E*, which carries the large punches *C*, *C*. As stated, these smaller punches are not included in the drawing.

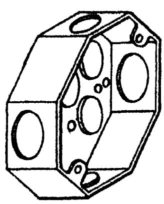


FIG. 102.—Detail of octagonal outlet box.

Directly below the five punches *C* are the knock-out punches *F* which assure the slugs being retained in the work when the latter is lifted or stripped by drawing ring *G*. The dies are operated on an air cushion under the press, and the work is stripped from the drawing punch by pins under drawing ring *G*, which are operated by the air cushion. Connections from the air cushion automatically blow the six small slugs off the air cushion. The spring-actuated punches *F*, already referred to, keep the five openings in the outlet box from being broken clear through and set the nearly severed slug closely in place as the box is stripped from the tools.

Dies for a Valve Spring Cup

The cup in Fig. 103 is formed with a channel around the base of the flange and a $\frac{25}{64}$-hole is pierced through the center of the piece.

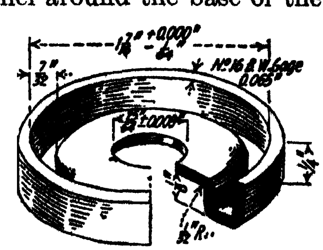


FIG. 103.—The spring cup to be made.

In the construction of the dies for this work, see Fig. 104, the blanking and forming ring *A*, is seated in a base *B*; the blanking punch *C* which serves as a guide for the forming punch *D* is fastened to a cast iron holder *E*. The part *F* strips the scrap from the punch. The knock-out *G* is supported by four push pins *H* abutting against the washer *J*, which serves as a retainer for the spring *K*, the tension of which is regulated by adjustment of nut *L*. The stud *M* which supports the knock-out arrangement is drilled through to allow the scrap punchings or slugs to escape. Slots are cut in the top

face of the punch holder to prevent the entrapment of air in the guide pin bushings.

In operation, the blank is cut from the strip by the punch *C* and forced down to the draw edge. The forming punch *D* and the piercing punch *N* then descend, completing the cup. As the press ascends, the punch *D* disappears through the opening of the blanking punch *C*, stripping the cup, while the knock-out ejects the cup from the die ring.

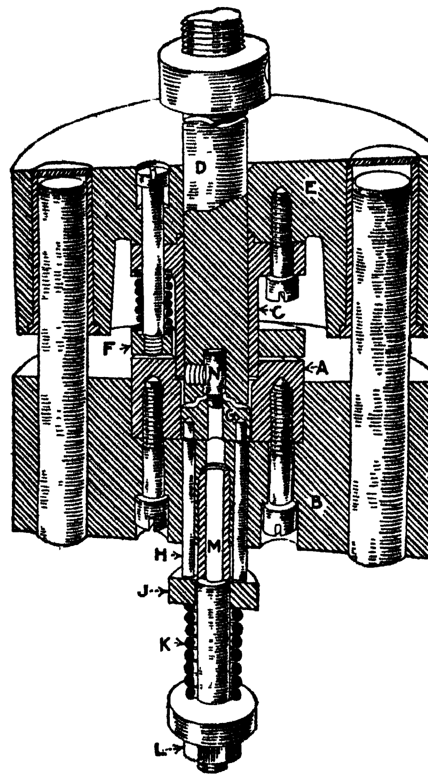


Fig. 104.—The combination die used.

Cup Tools

The combination blanking, drawing, forming, and piercing die in Fig. 105 is used in a single acting press for making cups. The parts are all designated by name to permit of easy reference, and a brief description of the action of the tools will suffice.

When the blanking punch descends, it enters the blanking die, and the blank is held firmly by the drawing ring against the bottom of the blanking punch to prevent wrinkling. As the downward movement continues, the blank is drawn between the bore of the blanking punch and the drawing punch. As it reaches the end of the stroke, the rim is formed between the shoulder in the blanking punch and the tapered shoulder on the drawing punch. The holes are pierced by punches located in the punch block and the dies in the base below. A spring stripper is used as represented. The knock-out is kept in line with the piercing punches by a Whitney key.

Set of Tools for a Brass Coupling

The pressed brass coupling in Fig. 106 is drawn in two operations. The first operation *A* consists in blanking and drawing from a $4\frac{3}{4}$-in. blank in the dies shown in Fig. 107. These tools are set up in a single action press and the shell must be drawn to a developed depth in order to correspond properly with the next operation dies so as to give the desired results.

In setting up this die, care must be exercised in adjusting the rubber buffer N. Too much stress on the pressure pad F would strain, stretch, and possibly break the brass, while not enough stress on the pressure pad would permit the metal to wrinkle and cause breakage and poor work in the operation that follows. The lower punch E in the die has a small

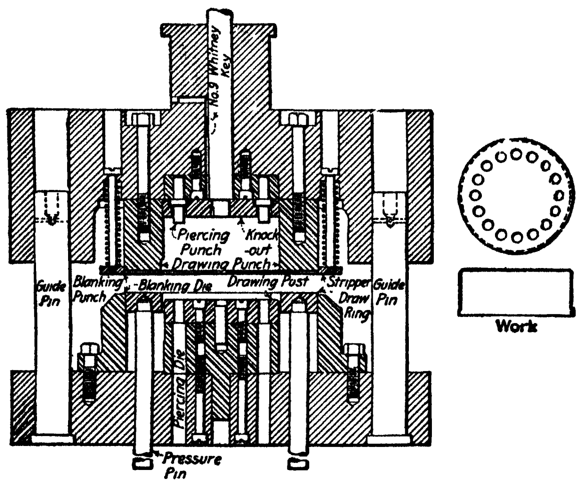


FIG. 105.—Blanking, drawing, forming, and piercing die.

vent to facilitate the removal of the work from the punch and prevent distortion.

The blanking punch A has a positive knock-out that comes in contact with the stationary knock-out bar attached to the press while in operation. Should the shell stay in the punch, it is easily released on the upward

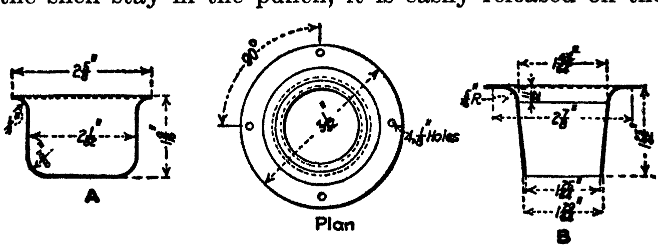


FIG. 106.—Brass coupling, No. 20 gage.

stroke. The compound blanking and cupping punch A is made of machinery steel with a tool steel bushing B pressed into place and secured by screws C. The bushing B which does the actual work of blanking and cupping can be shrunk several times when it wears large and is easily replaced with a new one when this becomes necessary. A punch of this type, when its diameter exceeds 4 in., is cheaper and has a longer life than a solid tool steel punch, because the bushings can be shrunk to size so often.

The blanking punch D, the forming punch E, and the pressure pad F are made of tool steel, hardened and ground to size. The forming punch E is held in position by the bolt H, which has a vent similar to that in the punch E. The outlet is at X. The blanking die has $\frac{1}{16}$ in. shear and is held in position by machine steel strippers I, in turn held in place by cap screws J and dowel pins K seated and screwed to the cast iron die plate L. The latter is secured to the bolster plate by cap screws O. The pressure pad pins M are made of hardened and ground tool steel and transmit the pressure to the pad F from the rubber buffer N, which is adjusted by the lock nuts P.

The second operation, indicated at B, Fig. 106, is performed in the drawing and perforating dies shown in Fig. 108. These dies draw the

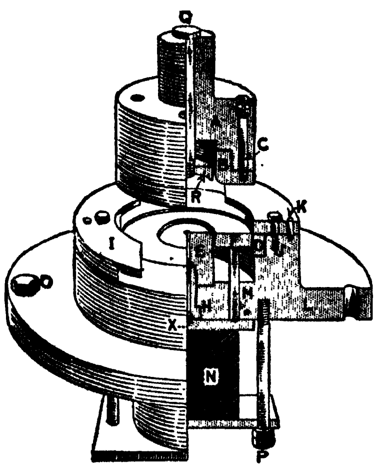


Fig. 107

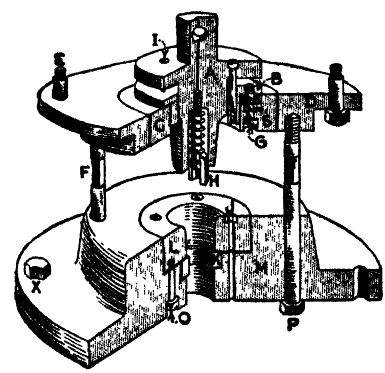


Fig. 108

Figs. 107–108.—Dies for a pressed brass coupling.

tapered shell B with a flange concentric with the walls of the shell, perforate four rivet holes in the flange, and punch out the bottom simultaneously. Thus the coupling is finished in two operations. By using a die of this type, trimming is unnecessary, so that it is possible to use a smaller blank, thereby saving valuable stock and completing the article in the briefest possible manner.

The drawing punch A, of tool steel, hardened, has double stripper bushings BC, made of tool steel, hardened and ground. The bushing C, connected with the bushing B by springs and screws G is screwed and pinned to the machine steel stripper bar D, which is held in place on the punch by the bolts E screwed to the ram of the press. When these bolts are properly adjusted, they give the correct sliding motion on the punch to release the stamping during the last $\frac{1}{4}$ in. of the upward travel of the press ram.

It is obvious that when the punch descends and enters the shell X the plug H (of tool steel, hardened and ground), having the proper spring tension will straighten the shell in the bushing C. This tension from the spring S causes the bushing C to close on the die on the last $\frac{1}{4}$ in. of travel of the punch, which is necessary in order that the surplus flange stock may be properly forced into the die and down along the sides of the draw punch, assisting the drawing and perforating the flange holes.

The punch A is straight for $\frac{1}{32}$ in. above the curve on the lower end to allow for the necessary over travel to upset the end of the coupling slightly and prevent it from having a feather edge. The perforating punches I are made of tool steel hardened and ground, and screwed into place by having their heads threaded and slotted. The perforating punches J are made of tool steel, hardened, ground, and pressed into place. The bushing K is likewise of tool steel, hardened and ground. It is held in place by the drawing die L, which is seated in the cast iron die plate M and secured by the screws O. The die plate is fastened to the press bed by cap screws X.

A Brass Bushing Outfit

The brass bushing at the extreme left of the parts in the foreground of Fig. 109 is blanked, drawn, and pierced by the tools at the right in the same

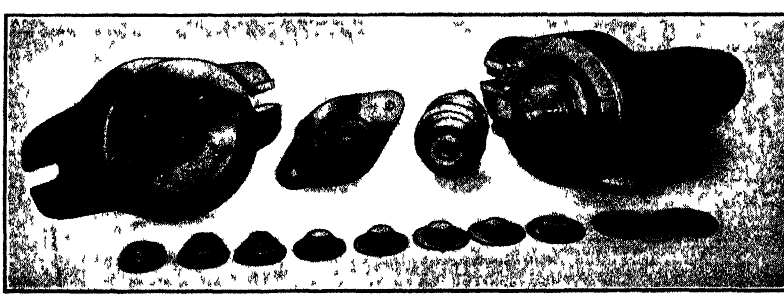


Fig 109.—Dies for a brass bushing.

photograph, and is then trimmed in the other dies at the left in the same engraving. A detail of the bushing is shown in the drawing, Fig. 110. The first operation tools are shown complete in the drawing, Fig. 111, and all details are included.

Referring to this drawing, the cutting edge of the blanking die is shown at A, and inside of this die is the compound drawing plug and ring B with the friction ring or pressure ring C filling the annular space between. The drawing plug B rests upon pressure pins D and the ring C upon longer pressure pins E which pass down through holes in the base of plug B and abut upon pressure plate F which acts uniformly upon both sets of pins D and E. Plate F is controlled by the rubber buffer or spring G which is

secured between F and a lower plate H, the latter being adjusted by the nut on the supporting length of tubing to allow the rubber to apply any desired degree of pressure to the friction ring and plug B above.

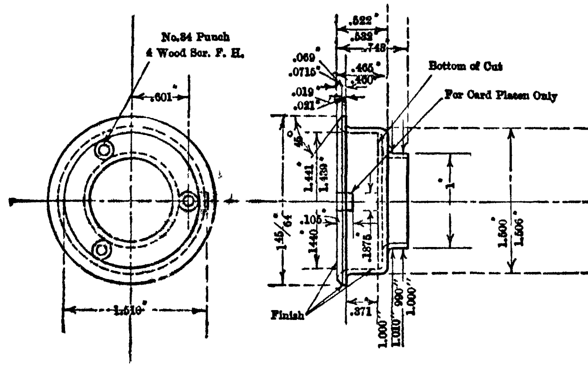


FIG. 110.—The brass bushing finished.

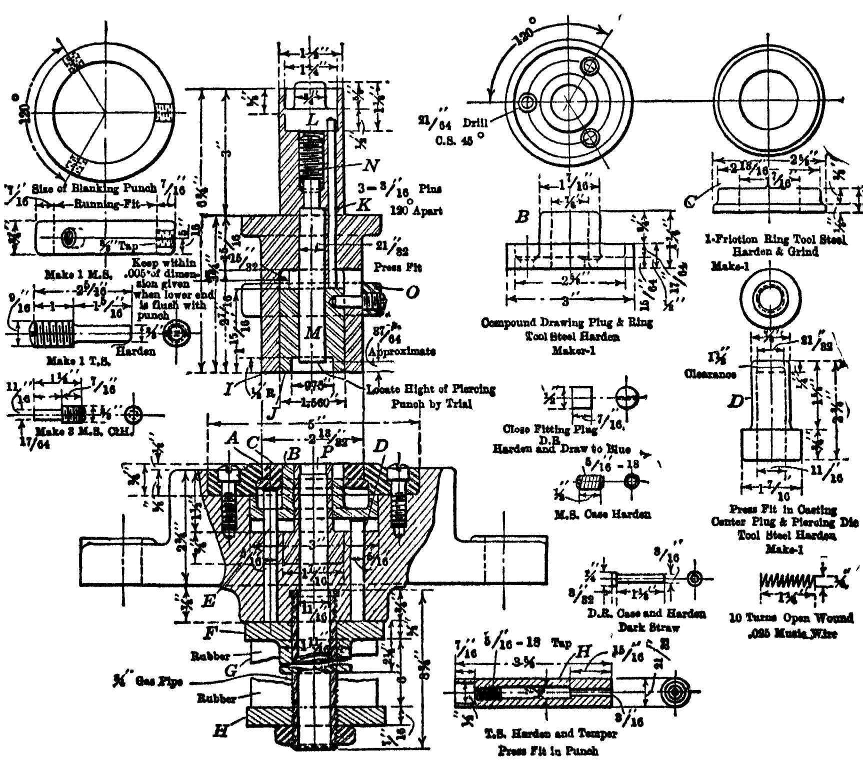


FIG. 111.—Details of combination blanking and drawing dies.

The blanking punch I is bored out and ground to 1.560 in. to form the drawing die inside for the larger diameter of the work and in this is fitted

the die J which draws up the smaller diameter at the end of the work. The latter die is adapted to slide upward for a distance of $\frac{1}{3}\frac{5}{2}$ in. and upon the up-stroke of the punch it is forced downward to flush position by the pins K and the knock-out plug L above. In the center of the punch holder is pressed snugly the piercing punch M which may be adjusted for depth of position by the screw N. The die J is stopped for lower position by the

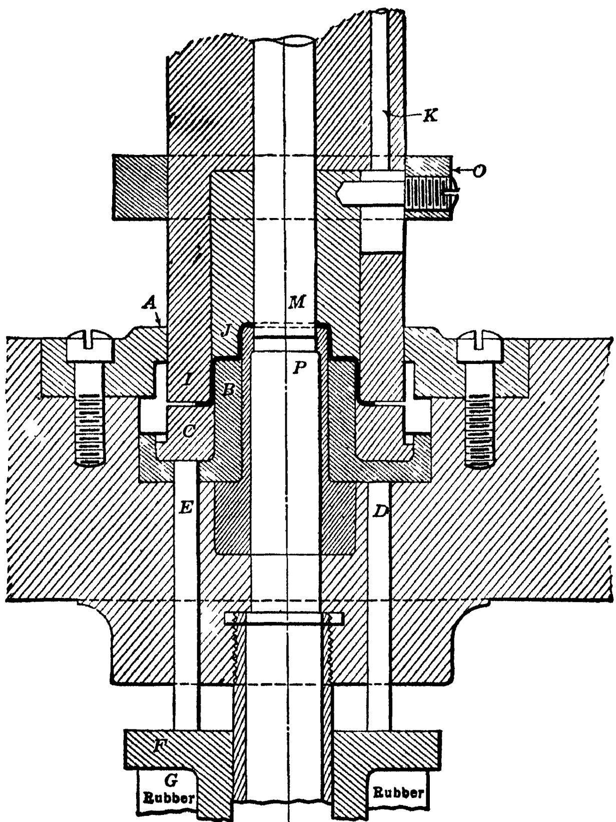


FIG. 112.—Blanking and drawing dies in operation.

ring O which encircles the blanking punch and which carries three screws passing through vertical slots in the punch wall and entering holes in the die J.

The piercing die is located at P in a seat bored in the die shoe or base and is relieved from the lower end to give a cutting length at the top of only about $\frac{1}{4}$ in. as shown by the detail at P.

The dies are seen in Fig. 112 as they appear with the work in place and drawn to shape for the two diameters and the hole pierced through the end. The same letters are here used for reference as in the other drawing just

referred to. The top surfaces of spring controlled members *B* and *C* act as friction surfaces or pressure rings to allow the two sizes of draws to be made without wrinkling of the metal. When the punch holder (which is made in one piece with the blanking punch *I*) rises, the knock-out *K* and ring *O* are actuated to eject the work from the upper dies. The scrap is stripped from the blanking punch by open stripper plates attached to the lower die face as shown in the photographic view, Fig. 109.

The Second Operation Dies

The trimming dies are illustrated by Fig. 113 and Fig. 114 shows the work in place and ready for the trimming of the edge in die *Q*. This die

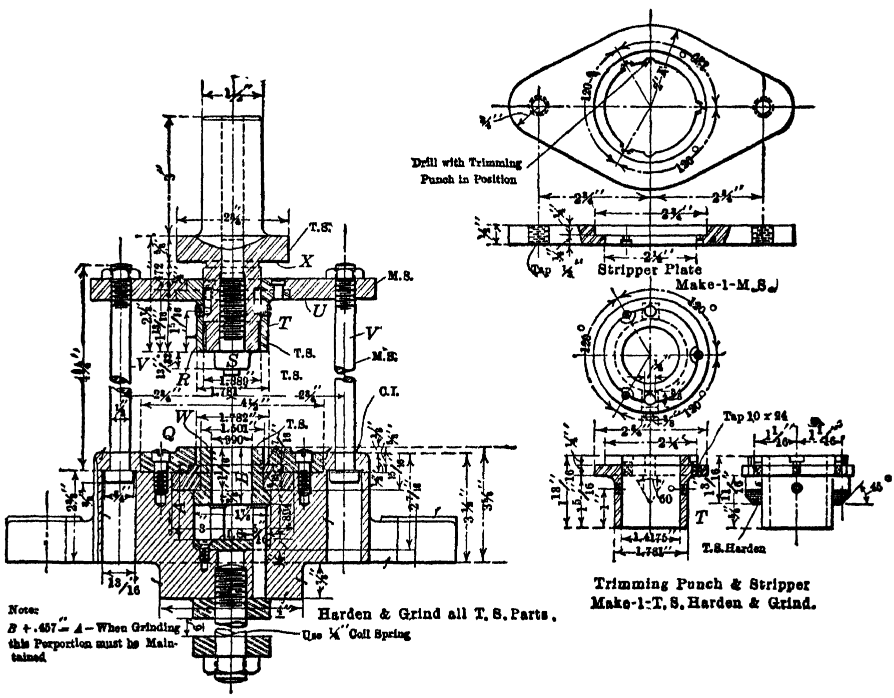


FIG. 113.—Construction of trimming dies.

(refer to both drawings) in conjunction with punch *R* trims the edge of the shell to 1.782 in. diameter. This leaves a small amount of stock which is finished to a perfect beveled edge in a later operation in a screw machine where the inside of the shell is turned out to a positive diameter and the end faced exactly to length, in accordance with the drawing of the finished piece in Fig. 110.

Referring again to Figs. 113 and 114, the work is centered by the piloted punch *S* screwed into the punch holder. This holder like the other is of tool steel and its lower end is finished by turning and grinding

to form the holder for the work. This portion of the punch also carries the combined trimming punch and stripper *T* which is connected with the cross plate *U* which in turn is connected with the lower die base by two sliding bolts *V* which prevent the stripper from rising beyond a certain point on the up-stroke of the press ram.

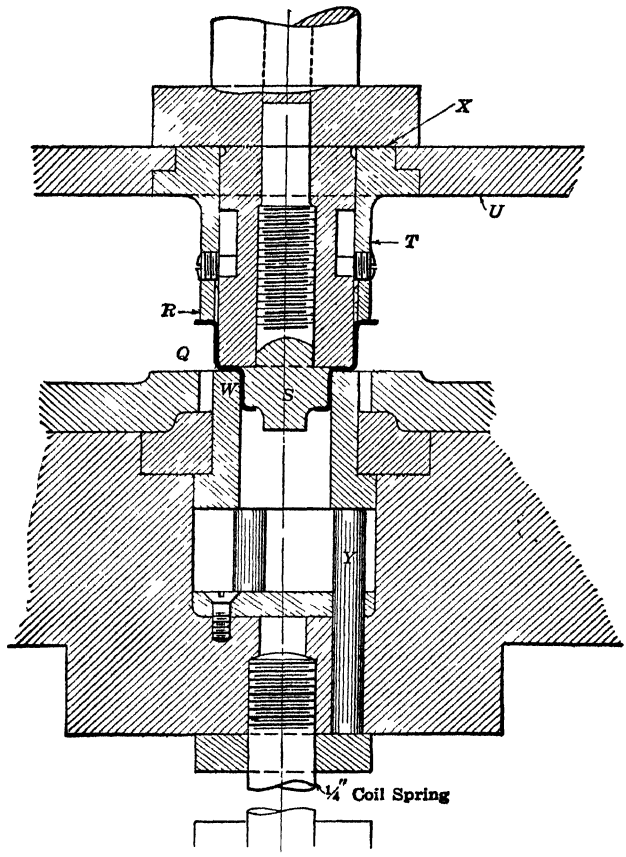


FIG. 114.—Trimming die in operation.

On the down-stroke, the locating punch *S* and the punch holder descend, as in Fig. 114, until the work is secured against the face of the trimming die pressure pad *W*; the top of the stripper plate *U* is then against the lower face of the punch holder shoulder *X* and the trimming punch *R* must then travel downward with the rest of the upper tools. The pressure ring *W* is forced down against the spring pressure transmitted by pins *Y* and the work is held securely while being pushed into the trimming die *Q*.

On the up-stroke of the ram, the pressure ring *W* carries the work out of the trimming die *Q* and when the stripper plate *U* reaches its limit of travel

upward, as determined by the stop bolts V, the punch holder continuing upward causes the ring and stripper R to strip the work from the punch. The stripper ring is provided, as shown in Fig. 113, with two wedge shaped points at the sides to split the thin ring of scrap trimmed off from the work as it accumulates on the surface of the punch and thus keep the punch clear.

It is evident that dies of this class must be set up in the press with some care to effect the desired results. Particularly with the first operation dies which draw two different diameters, judgment must be used to adjust the different elements properly to assure the correct distribution of metal between the two sizes drawn on the one shell. To facilitate the setting operation the set of standard pieces or models shown in the foreground of Fig. 109 are kept available. These pieces are made up to represent correct heights and sizes of draw for the shell for every sixteenth inch of movement on the part of the press tools. Thus, when the tools are being set, the operator can draw a blank to the first sixteenth of depth and compare results with the model parts used for comparison gages, and so on with the setting adjustments until each advance of the amount specified, or $\frac{1}{16}$ in., produces a partially drawn shell corresponding in all dimensions with the models, or masters shown, and the completed trial piece becomes a duplicate of the full drawn model.

Drawing Fine Wire Mesh

One more example of a set of blanking and drawing tools will be shown in this chapter. The tools in Fig. 115 are for an unusual piece of work, a

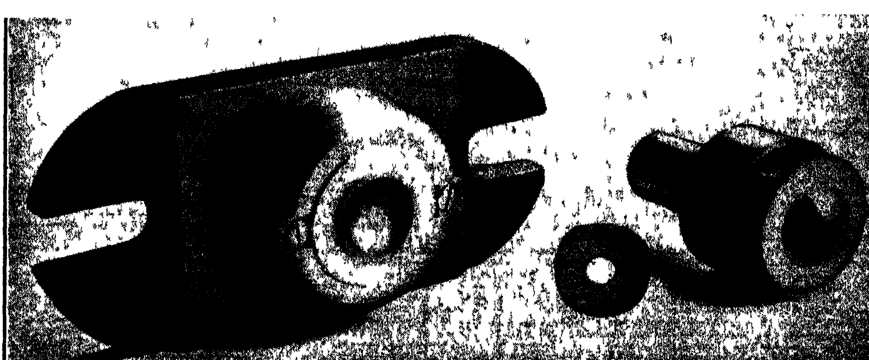


Fig. 115.—Tools for a fine mesh screen for a carburetor.

fine meshed copper wire screen for a carburetor. This would appear to be difficult material to work in the press, but with the tools illustrated no trouble whatever has been encountered.

The wire screen is shown in Fig. 116 somewhat more clearly than in the view of the dies. The dimensions are given in the sketch, Fig. 117, which

shows a vertical section through the dies. The wire screen is drawn up to a diameter of $1\frac{3}{4}$ in. and to a depth of about $\frac{5}{8}$ in.

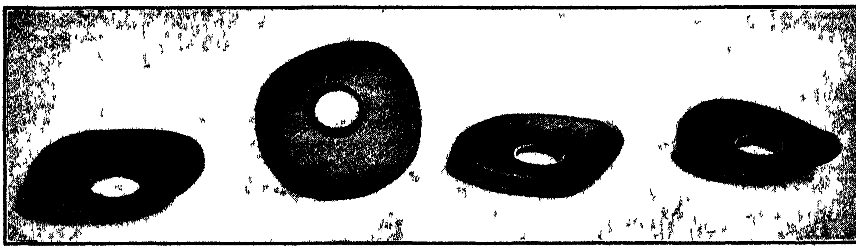


FIG. 116.—The small screens as they appear when fitted with center ring.

The tools are so made that although they blank and form and pierce in one operation, the drawing operation, or forming, is accomplished first, the wire being pressed down into the spherical seat in the pressure pad A

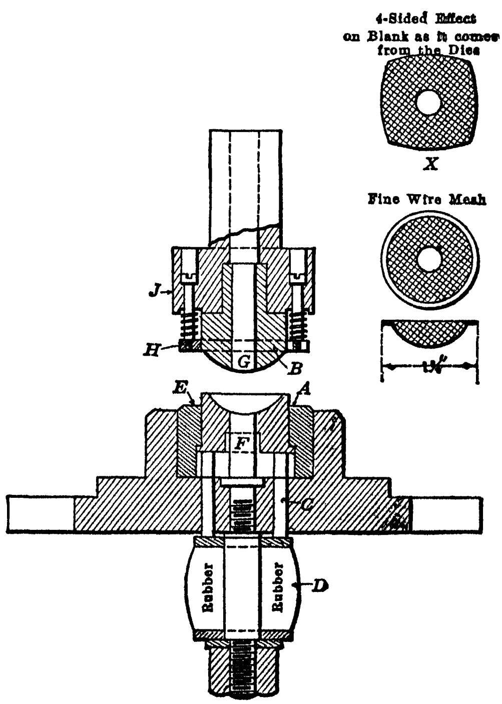


FIG. 117.—Construction of tools for screen.

and held there by the punch B and the action of the pressure pins C and the rubber buffer D below, while the blanking is done with the cutting edge of the punch and the blanking die E. At the same time the piercing

punch F pierces the hole through the center, the piercing die being formed at G in the center of the punch B.

The stripper is carried at H on three small screws with springs between stripper and punch holder, J. As the work leaves the dies it tends to spring back to an approximately flat form, as seen in Fig. 116, and it will be noticed that the outline of the screen is four sided with slightly rounded edges but otherwise closely resembling a square piece. When assembled in the carburetor it is placed in a circular seat and there retains its hemispherical form. The brass eyelet shown at the center is, of course, set into place in a subsequent operation.

DIES FOR HANDLING THIN STOCK

Some of the details to be considered in the design of dies for blanking and drawing or blanking, drawing, and perforating thin metal, under 0.020 in. thick, are given in the following pages as described in the *American Machinist* by Wallace C. Mills. This authority states that such dies are similar in many respects to dies for thicker stock but may vary in other details, such as clearance, die hardness, and certain other details.

Figure 118 shows a die for blanking and drawing a simple 0.010-in. thick shell, such as a can cover. In the design of such a die for thin metal, particular attention should be given to the details:

1. A plain die set without liner pins is preferred for a round die, because the stampings, when blown out of the die, may strike the pins and interfere with rapid production. Also, a plain die set is less expensive than a liner-pin set. If the work is square or has irregular perforations, however, a liner-pin die set is preferred to facilitate setting up of the die in the punch press.

2. The punch and cutting ring of the die should fit without clearance to ensure a clean cut of thin metal. The punch is turned and ground to the same diameter as the cutting ring, then peened and forced through the die. The cutting ring is made of oil-hardening steel, hardened to 62 Rockwell C. The punch is made of water-hardening steel hardened to 42 Rockwell C to permit peening.

To allow for wear, the punch is made as long as possible. For metal thicker than 0.020 in., clearance would have been allowed equal to a tenth the thickness of the stock, and both cutting ring and punch would have been hardened.

3. The cutting ring has $\frac{3}{4}$ degree taper clearance, which may run clear to the top of the cutting ring. The punch is tapered back smaller at the top by 0.001 in. per in. to avoid scoring.

4. No stripper has been provided on this die for stripping the stock from the punch, because there is a gain in production and a saving in

stock by running "pull through" as shown in Fig. 119. The stock is pulled by hand against a stop set flush with the edge of the cutting die. The stock breaks through between the blanks, and the strip spreads open while it is being pulled through.

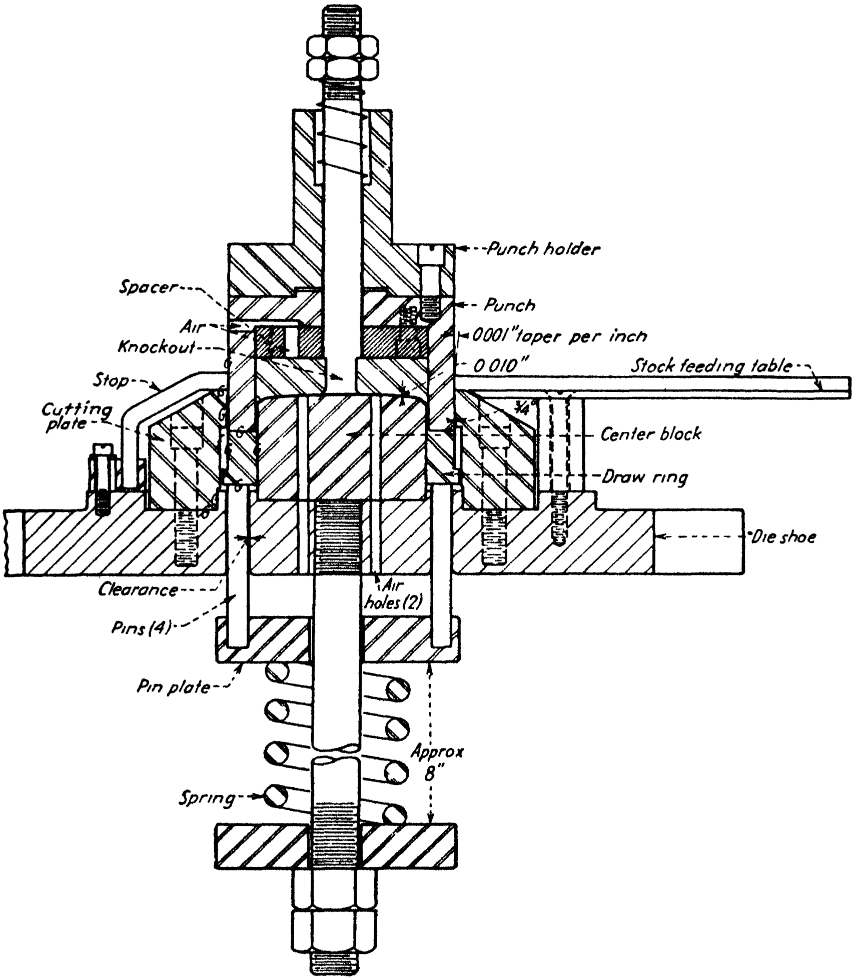


FIG. 118.—Showing details recommended for thin-metal dies: (1) no clearance between punch and cutting ring, (2) a knockout spacer to ensure bottoming, (3) ground surfaces to maintain alinement, and (4) shims to raise cutting ring when it is ground low.

5. Round dies are provided with devices for maintaining concentric alinement of their respective parts to avoid pinching the stock. Certain surfaces are ground and set against concentrically turned surfaces, and offsets are provided to maintain alinement when the cutting ring is raised by shims because of wear and grinding. Square dies are provided with

dowel pins only for maintaining alinement instead of concentric surfaces, because squared dies are more difficult to machine.

Devices for maintaining concentricity in round dies and the surfaces that must be ground and those that need not be ground are shown in

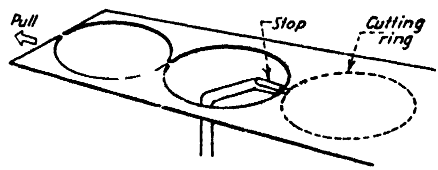


FIG. 119.—Pull-through stock feeding saves material, as no web is left between blanks, and no die stripper is needed.

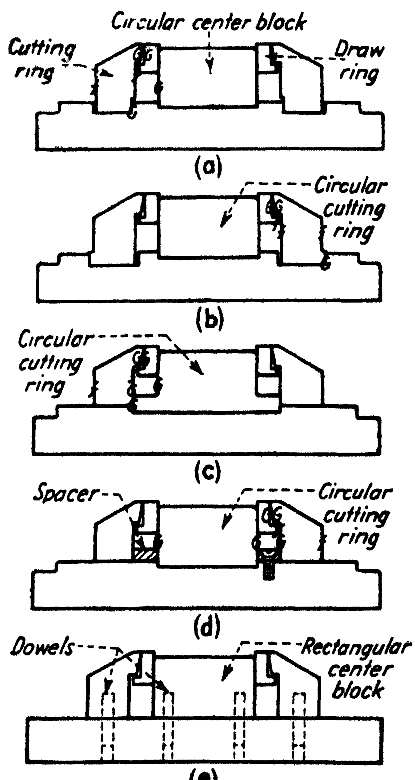


FIG. 120.—Views (*a*) to (*d*) show alternative methods of maintaining alinement in circular dies. View (*e*) shows a rectangular die with a doweled center block and cutting ring.

Fig. 120, *a* to *d*. Figure 120 *e* shows a rectangular die fastened with dowels.

Other details of construction in Fig. 118 which should not be overlooked are

6. The die should be built with the top of the cutting ring and the draw ring $\frac{1}{8}$ in. above the top surface of the center block to allow for initial wear and grinding. When the cutting ring has worn down to the level of

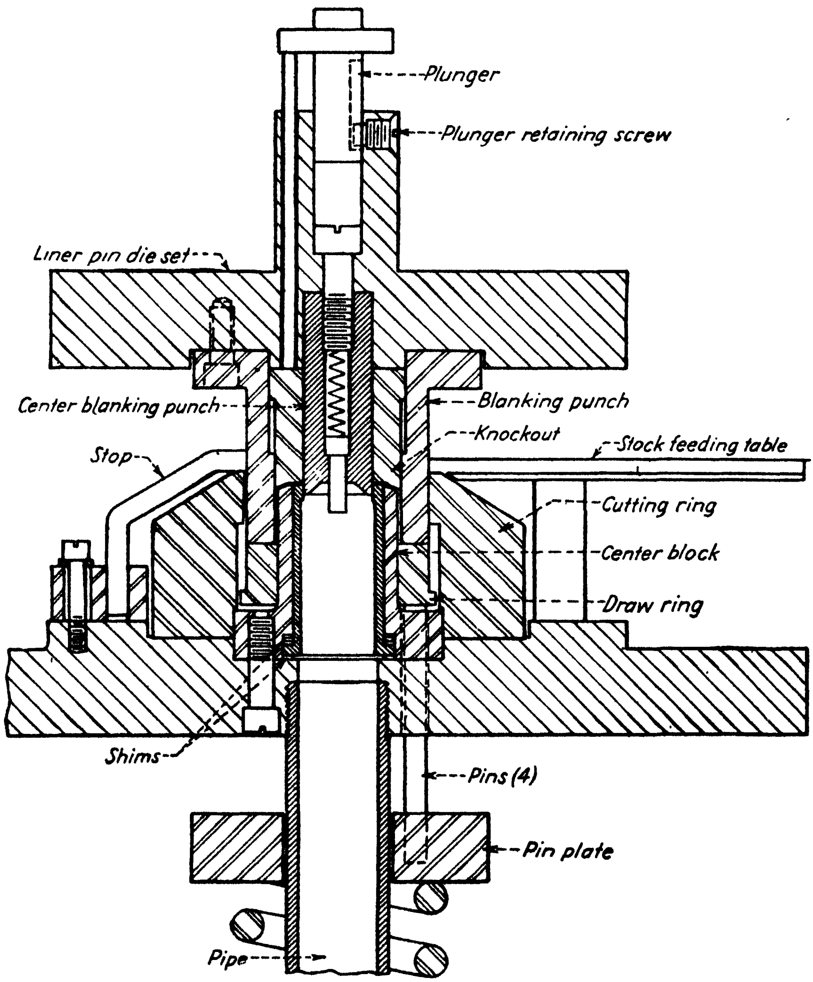


FIG. 121.—This die for thin stock combines center blanking with blanking and drawing. The blank is drawn before the center punch cuts to avoid distortion of the center hole.

the center block, it can then be shimmed up, the alinement being maintained by the offsets.

7. For stampings having panelled tops, the knockout should strike a solid bottom in the punch so the stamping is hit hard between the knockout and the center block. A spacer, provided between the punch and the knockout, can be ground thinner when the punch is ground shorter

in sharpening. Otherwise, the punch would not enter the die deeply enough to draw the stamping to full depth. For stampings having a flat top surface without a panel, the knockout need not bottom.

8. A spring in the punch holder should counteract the weight of the knockout so the punch will pick up the work more readily. Exception to this rule is made in certain dies for perforating small holes. In this case the knockout should not be held up, because it cannot then support the slender perforating punches close to the die.

9. Two air holes should be provided in the center block of the die. Only one air hole, off center, might cause the work to tilt when it is lifted from the center block.

10. At least one dowel pin should be provided for round parts that are ground and fitted into a recess. When there is no recess, two pins are required.

11. The corner drawing radius of the punch must be found by trial. Too sharp a radius will tear stock, whereas too large a radius will cause wrinkling. The inside surface of the punch should be ground by starting with an inside diameter 0.002 in. larger than the diameter of the center block plus two thicknesses of stock. The diameter of the punch can then be enlarged as needed. The flat drawing surface of the punch and the top of the draw ring should be lapped.

12. Use of screws extending downward from the cutting ring to the die holder permits removal of the cutting ring for sharpening without removing the die from the punch press.

13. Pins of the pin plate should be of such length that, when the punch is up, the pin plate strikes the bottom of the die to relieve pressure on the screws that hold the cutting ring to the die shoe. The holes through the die shoe should be $\frac{1}{64}$ in. larger than the pins to avoid any binding action, and should be countersunk to remove burrs formed by drilling.

14. Drawings should show corner radii instead of sharp corners on hardened parts wherever possible. This is a small point that may cause a great deal of trouble if neglected.

15. The screws should not be smaller than $\frac{5}{16}$ in. in diameter wherever possible because $\frac{1}{4}$-in. screws are too small at the thread root.

Figure 121 illustrates a die for center blanking combined with blanking and drawing. On such a die, the center blanking punch should not cut until the stamping has been drawn to its full depth. Otherwise, pulling of the stock while center blanking will enlarge the hole. The center punch should be provided with a spring pin for pushing the slug through the die.

The bushing, which is the center blanking die, should be provided with shims which may be removed and built up under the bushing to raise it when it is shortened by sharpening. The bushing is given a $\frac{1}{2}$ degree

taper and hardened. The center blanking punch, however, is made semi-hard and forced through the bushing to eliminate clearance.

As the center blanking punch of this die is located in the middle directly under the punch shank, it is difficult to arrange the knockout to operate from the pins in the shank of the punch. The construction may vary, depending on whether the center blanking punch is smaller or larger than the diameter of the shank. Various modifications are possible to suit conditions.

Section V

BENDING AND FORMING TOOLS AND OPERATIONS

CHAPTER XIII

METHODS OF BENDING AND FORMING

Tools of the type used for such operations as bending and forming metal parts are extremely useful and time saving in their effects. Like other classes of press tools they eliminate a great amount of work that would be required if simple bench devices were to be used in their place, but there are many instances where such devices have been employed to save the first cost of adequate dies.

Many operations of the bending class can be performed by holding fixtures in the bench vise, though this cannot be recommended except in

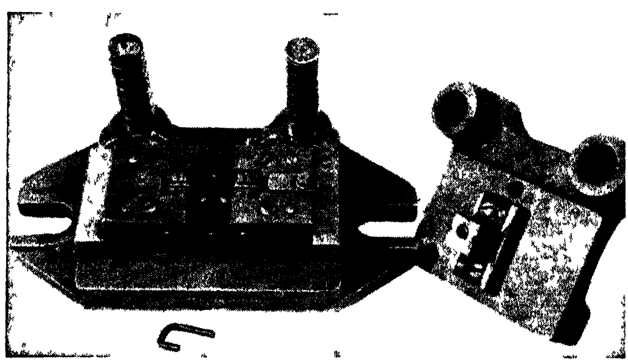


FIG. 1.—A bending die with rolling formers.

such instances as where there are so few parts to be made that even elementary press tools are out of the question. Probably these cases are rare and, in any event, the cost of fixtures, that would produce work with a close degree of accuracy comparable to what can be done in the press, is quite enough to warrant the expenses of real mechanical tools of the stamping press class.

Elementary types of bending tools consist of dies for operating on small flat blanks or on round or square wire. Such dies may be for the purpose of making irregular bands or for forming the piece into a right-angle blank.

An ingeniously designed die for a small wire-bending operation forms the subject of the first illustration in this chapter, Fig. 1, these tools being constructed for producing the hook-shaped piece of wire seen at the front of the die shoe. The bending operation is accompanied by

a forming operation applied to the central portion of the loop of wire giving it a swaged and flattened form.

The wire is nearly $\frac{3}{16}$ in. in diameter. As it goes into the bending dies it rests upon two oscillating or roll-over dies, which are grooved in their upper faces as shown. These two dies are mounted upon trunnions which, as the punch descends, allow the dies to roll toward each other as the wire is forced by the punch down between them. The side faces of the punch are similarly grooved with a half-groove, and the dies in rolling toward the punch force the wire snugly against the punch faces. Thus the wire is formed to a right-angle bend at its corners, and the bar joining the two fork ends is formed as shown by the sample in the engraving, Fig. 1. When the punch ascends, the wire emerges from the dies; and they are rocked back to normal position by the two coil springs at the rear, which are attached to short levers at the back end of the die trunnions.

This die is illustrated here as an application of important mechanical principles to the production of what appears a simple object but which requires nevertheless the exercise of considerable experience in the selection of type of design best adapted to the production of the work.

Use of the Spring or Pad Knock-out

Another type of die for small, round pieces is shown in Fig. 2. This is a simple piece of bending work with a spring pad in the dies as shown.

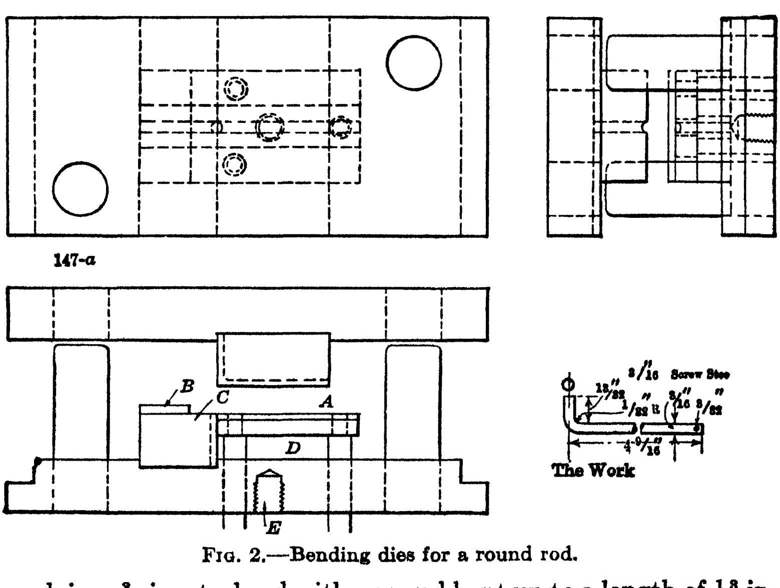


Fig. 2.—Bending dies for a round rod.

The work is a $\frac{3}{16}$-in. steel rod with one end bent up to a length of $\frac{13}{32}$ in., the body being $4\frac{9}{16}$ in. long. The dies require little description. They are made with guide pins for alinement and rigidity, and the upper

and lower dies proper are concaved for one-half of the diameter of the rod in each face. The pad A is provided with a similar half round groove and the work is readily located by slipping it into this concave seat and resting its inner end against stop shoulder B. On the down-stroke, the rod is forced down over the rounded corner of lower die C and formed to the right-angle bend desired. When the upper die ascends, the spring pad A lifts the work clear and is ready for another blank. The dies and pad are made of tool steel and hardened.

The pressure pins D are actuated by a spring pressure attachment whose supporting stud screw into the tapped hole in the lower die shoe at E. This is similar to the usual spring attachment used with various classes of dies already shown in this book and need not be detailed here.

Bending Two Ears on a Blank

In Fig. 3 (at the right) are a pair of dies for bending up two lugs or ears on a bracket shaped piece shown in detail in Fig 4. This is pierced

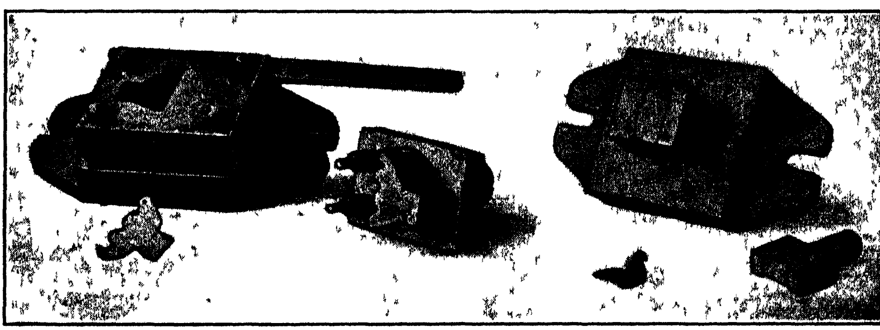


Fig 3 —Blanking, piercing, and forming dies for a small bracket

and blanked with the tools at the left in Fig. 3, the form of the blank being clearly represented in the detail sketches. The piece is made from $\frac{3}{64}$ in. steel, and has two $\frac{1}{8}$-in. holes pierced in the end which are later used in the finished work for receiving a rivet or pin for hinging another member between the bent up arms.

The two pierced holes are made use of for locating the blank on the bending dies shown more fully in Fig. 5. The die proper here is seen at F and the punch or upper die at G. Die F is cut out midway of its width to receive a pressure pad and ejector H which is formed at the front end to give the downward bend to the lip of the blank. In this way it is made to form part of the die itself in that it performs a portion of the work of shaping the piece to dimensions. A counterpart of the bend, but in the reverse direction, is formed on the end of the punch G. The latter is naturally less in width than the opening O across the die face by an

amount equal to twice the thickness of the material. As with drawing dies it is desirable to give the corners of the bending dies a liberal radius to enable the work to pull over and down the side of the die without breaking or tearing. This also enables the bend to start easily.

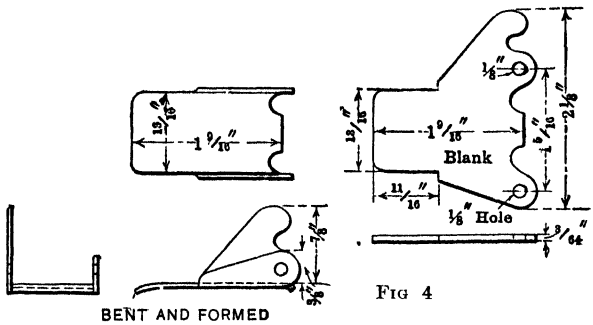


FIG 4

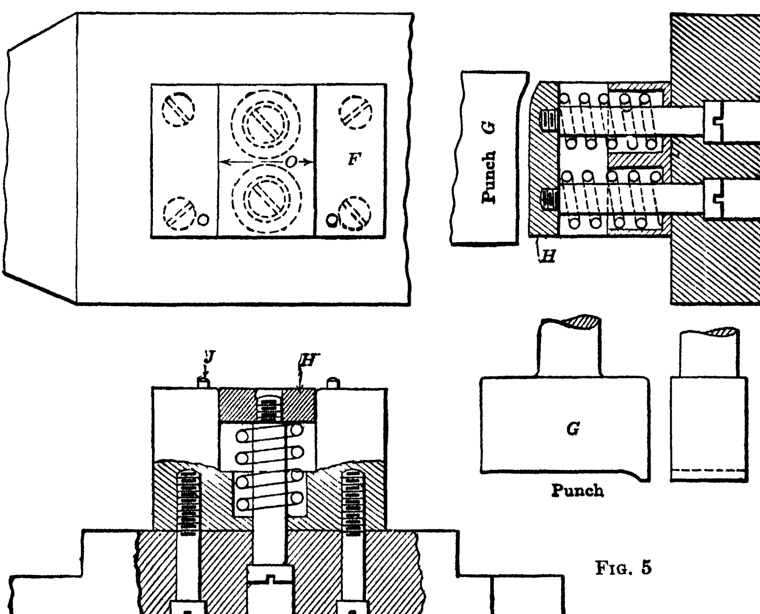


FIG. 5

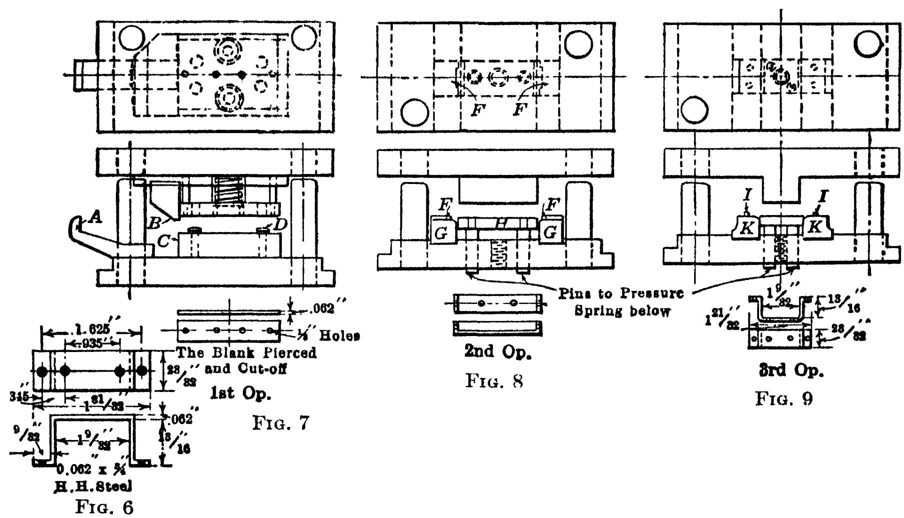
FIGS. 4-5.—Construction of bending or forming die.

As the punch comes in contact with the blank, the projecting ears on the blank swing upward and release the work from the very short locating pins J and the punch continuing downward presses the blank down between the die jaws and forms it to shape. With the return of the punch, the spring pad F carries the work up and out of the die.

A Double Bending Outfit

Where simple tools are preferred it is often necessary to use two or more sets of bending dies for performing the same number of distinct operations on a piece. With compound bending tools parts requiring complicated bending and forming operations are completed in one setting.

The work shown in Fig. 6 is a steel bracket $\frac{1}{16}$ in. thick which is blanked and pierced in the tools, Fig. 7, where the blanking operation consists in shearing off the end of a strip of the right width and piercing the holes at the same stroke of the press. The end of the strip rests against stop *A* after the first stroke of the press and this gives the right



Figs. 6-9.—Dies for double bending operation.

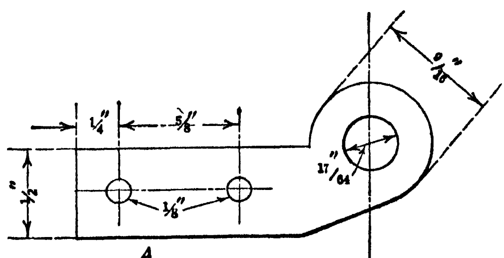
position for cutting off to length by the shearing punch *B* and the cut-off end of the die *C*. With such small punches, as are here used, it is desirable to have the cut off punch act first before the piercing punches enter the work, thus preventing the latter from being injured or broken. The strip of material rests between the gage studs *D* while in the dies and the four gage stops thus hold the strip central and square during the operation. Their heads also form a stripper.

The first bending operation consists in turning up the ends to a right angle with the dies in Fig. 8. Here the blank is placed in the die with the ends between stop surfaces *FF* which form a locating nest while the punch descends and draws the work down between the bending jaws *GG*. The knock-out *H* is supported by two pins which abut upon the spring pressure device below, and when the punch ascends, the spring pins carry the work up for removal and transfer to the next operation dies, Fig. 9.

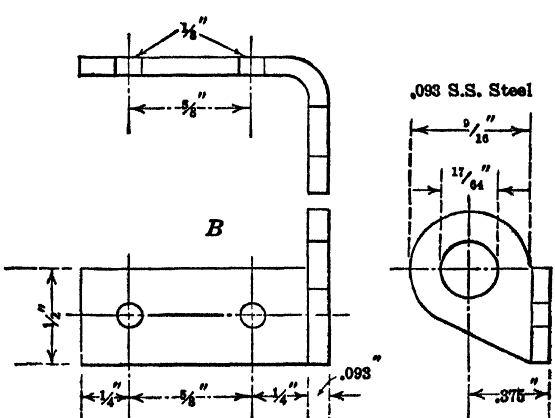
Here the work rests over the two gage pins *II* and the punch in descending performs the second bending operation by forcing the middle of the bent blank down between die jaws *KK*, where the body of the piece is formed to the outline indicated in the sketch of the third operation. The action of the knock-out is the same as with the one in the first operation die Fig. 8. The die jaws, punch, and strippers here are of tool steel, hardened, the pressure pins of drill rod hardened, the die base and punch holder are machine steel plates finished to 1 in. in thickness.

The Pressure Pad on Top of the Work

It is occasionally the case that the die is designed to hold the work blank on top of the anvil or flat part of the bending die by means of a



The Pierced Blank



The Work Bent to Shape

Fig. 10.

pressure pad while the punch or upper die is engaged in bending some projecting portion of the piece. In this case the work is placed in some form of nest or located over gage pins, and when the punch descends, the pressure pad holds the material firmly for the forming of the bent portion. An example is illustrated in Fig. 10 which is a sketch of a small bracket

for a register device, where the round end is bent at right angles to the body.

The piece is pierced and blanked in progressive dies in an earlier operation and the form of the blank is shown at *A*. The shape of the member after bending is seen at *B*. The material is 0.093-in. soft rolled steel.

The bending dies are shown in Fig. 11. The work is placed over the two pins in the face of the die block *C* and is held squarely by these pins for the application of the bending punch *D*. As the punch holder descends,

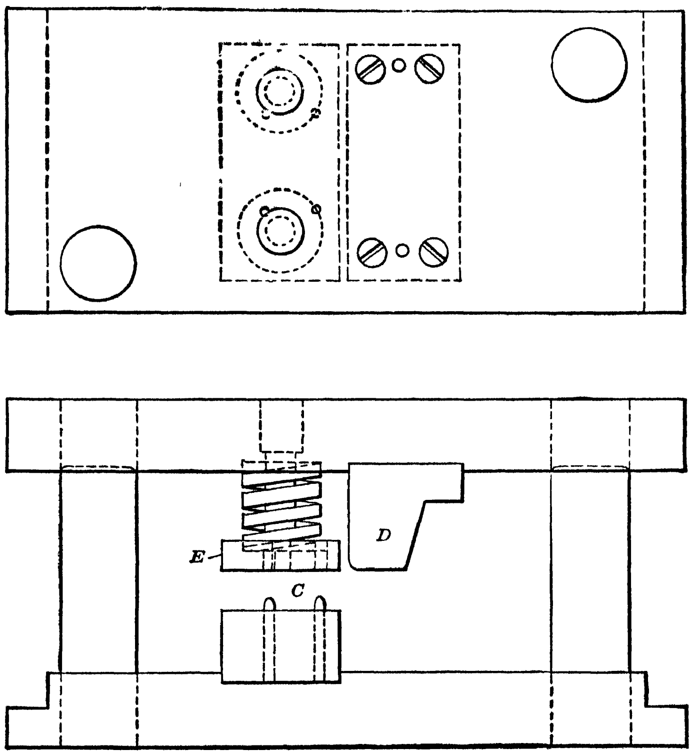


FIG. 11.—Bending dies for a light bracket.

the pressure pad *E* which is backed up by a very stiff spring, is forced down upon the work and held securely during the folding down of the end over the edge of the die. When the punch rises again, the pressure pad follows it and the work is released.

Two blanks are bent at once in these dies. This means a wider pressure pad than would be required for a single blank and the proportions of the pad are therefore made such that two springs may be used and a better balanced action is thus made possible. The work is placed and removed as readily as a single blank would be and there is a great advantage in output from this arrangement.

The desirability of the guide pins for the punch and die bases is obvious as without them there would be much sacrificed in the way of rigidity of the tools. The pressure and thrust all being in one direction, there would be more or less difficulty in the unsupported dies through tendency toward displacement of one member or the other of the pair.

As with other dies shown, the die block and bending punch or upper die are held to the die base and punch plate by fillister head screws and dowel pins. The pressure pad is carried by two fillister head screws whose heads are free to travel in the counter-bored holes in the punch plate.

Knock-out for Both Punch and Die

Figure 12 illustrates a case where knock-outs are applied to both punch and die for certain operations in bending. The work is part of a sheet metal hinge appearing when completed as shown at *C*. The blank is seen at *A* and the first bending operation produces an article illustrated at *B*. The piece is made of 0.0625-in. sheet steel, $1\frac{1}{2}$ in. wide.

The first operation tools, Fig. 13, pierce the six holes and cut off the blank from the strip of steel. The stock, after the end has been trimmed off, is fed to the stop *E* which is adjustably secured by two cap screws. After the first cut, the dies work progressively and a blank is pierced and cut off at each stroke of the press, and falls through the open die shoe as cut off. The cutting-off punch will be seen to be longer than the small piercing punches so as to sever the piece before the punches come into contact with the stock. As pointed out at another place, this is to prolong the life of the punches.

It is also essential to make the stock guide slot in the stripper no wider than is necessary to allow the stock to slide. As will be noticed, the cutting-off punch *G* is cut out at *I* for the purpose of providing room for the machine steel punch plate *J* which, with the cutting-off punch, is secured to the punch holder *B* by fillister head screws and dowel pins.

The second operation punch and die, Fig. 14, bend the blank to the form at *B*, Fig. 12. The cast iron die shoe *A* has two hardened tool steel blocks *B* mounted upon it and held by four fillister head screws through the shoe. The forming punch *C*, of hardened steel, is secured by four screws to the cast iron punch holder *D*. The stops *E* locate the blank centrally and sidewise over the die. Spring knock-out pins are provided for both the punch and die. The right tension for the knock-out spring for the punch can be secured by adjusting the screws *F*, while the knock-out spring and pins in the die have means of adjustment through the screws *H* and the nuts *I* and *J*.

The third operation punch and die are illustrated by Fig. 15. The sectional view at *A* shows the simplicity of construction of these tools. The hardened tool steel die block *C* is mounted on a cast iron die shoe and

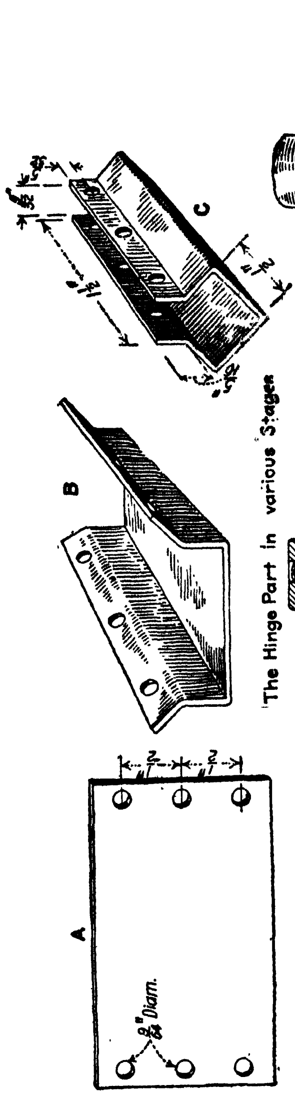


FIG. 12

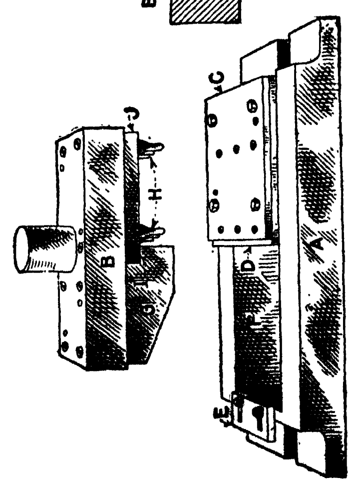


FIG. 13

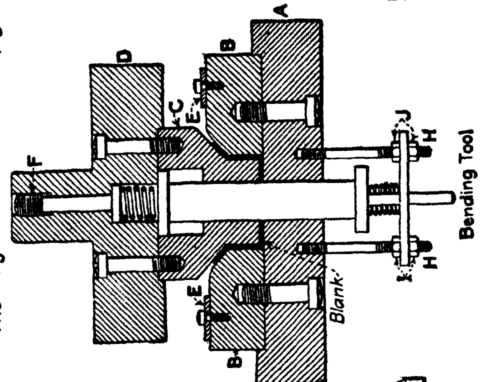


FIG. 14

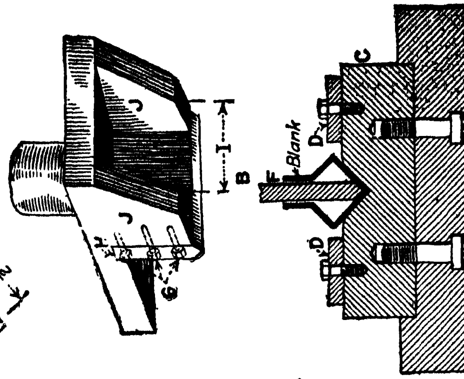


FIG. 15

FIGS. 12–15.—Press tools for a sheet steel hinge part.

held with screws as is clearly shown. Gage stops D locate the work in relation to the V form of the die. The forming punch F, which is of necessity very slender and therefore subject to breakage, has to be reinforced without in any way interfering with the die or the work. The way in which this is accomplished is shown at B, Fig. 15. The forming punch rests in the slot H and is secured to the webs J of the punch holder by six screws, as indicated by dotted lines G. The distance I is ample to clear the width of the die block so there is no interference.

By using this method of mounting very thin forming punches the danger of bending or breaking is eliminated, and the replacing of old punches is simplified.

Floating Work Supports

The principle shown in Fig. 15 of striking a blank in the middle for bending up the ends hair pin fashion is often applied with first bending

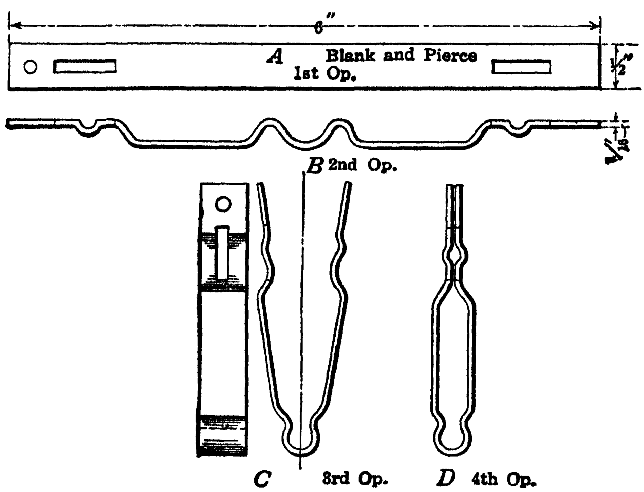


Fig. 16.—Operations in a formed and bent spring clip.

operations as well as with the second or forming operation illustrated in that view. And where a blank is so bent to a U form with arms that require closing together, as with, say, some form of spring clip, the work may at times be supported upon a type of floating holder that allows the piece to be carried down into the die and, upon its release from the upper die or punch, to be lifted clear from the dies for removal by the operator.

A case in point is illustrated by the bent and formed spring pin, Fig. 16, which is manufactured from $\frac{1}{16}$-in. steel, $\frac{1}{2}$ in. wide. This steel piece is first pierced and cut off to length in dies like those in Fig. 4, Chapter IV. It is then placed in the forming dies, Fig. 17, where the central loop and the various other bends are made crosswise of the stock. These dies are simply upper and lower shoes of cast iron with hardened steel forming

blocks inserted in their faces and secured by fillister head screws and dowels. The die blocks are provided with end shoulders to form a locating device for stopping the end of the blank from passing over the

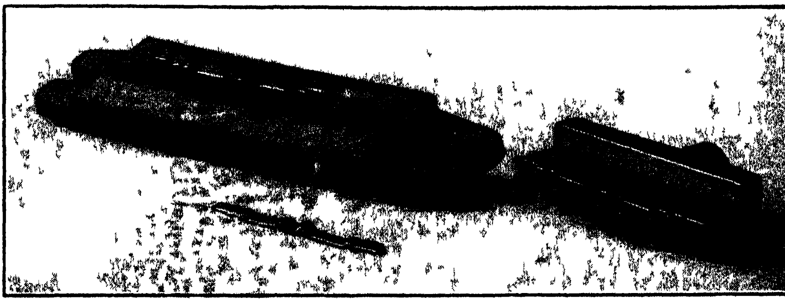


FIG. 17.—The first operation forming tools.

end of the die. One down-stroke of the press forms the blank to the corrugated slope at *B*, Fig. 16. It is then ready for the bending dies, Fig. 18.

The latter drawing shows the work in place and bent up by the downward pressure of the punch. The punch is a T-shaped tool with a narrow

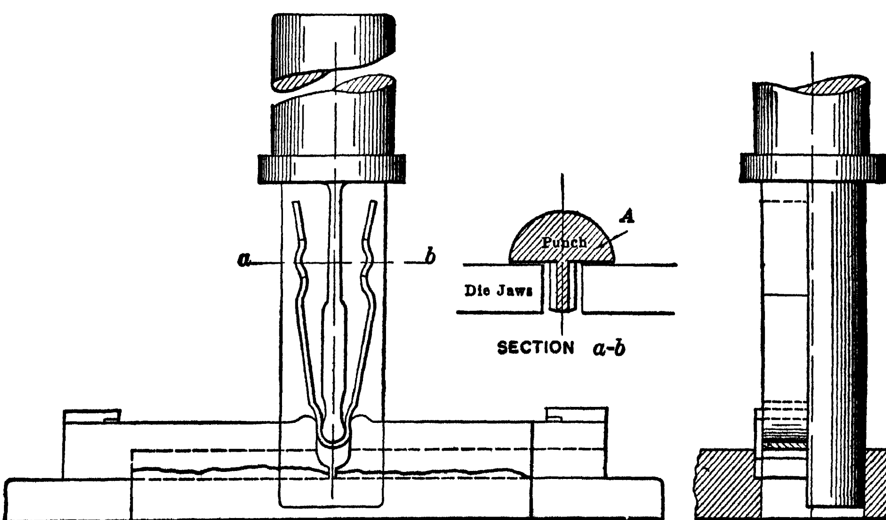


FIG. 18.—The bending die construction.

portion crosswise of the end to produce the bending action at the middle of the work; the back of the punch is virtually reinforced for rigidity and strength by the portion of the body which has not been cut away in forming the bending section. This leaves the cross section of the punch as at *A*, Fig. 18, with a full half circle which is used as a guide in the

descent of the punch into the die, the latter being bored at the center to form a bearing for the back of the cylindrical punch surface.

The die blocks are in the form of jaws with well rounded upper corners and with stop gages at each end for centering the work. As the punch descends and forces the work between these jaws, the action of the two elements, punch and jaws, is to bend the work to a small circle in the middle corresponding to the similar form on the end of the punch. This circular curve merges into the concave curve directly above on the punch and the die jaws are so shaped as to conform to this and give a cleanly bent piece, like C, Fig. 16. The ends of the work spring apart as the

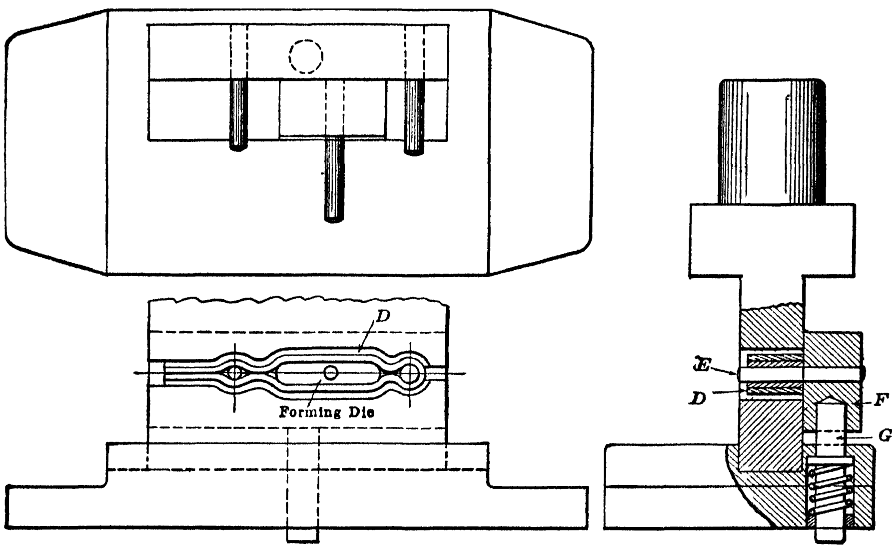


FIG. 19.—The finish forming dies.

piece is removed from the punch on its up-stroke and a fourth operation is used to close the ends as at D, in the same engraving.

It is here that the carrier is provided to receive the work from the operator, allow it to be forced down into the dies, and finally, return it to clear position for removal.

The finish forming dies are represented by Fig. 19. Referring to the latter view, the work is shown at D, in the dies, with the dies closed upon it. It is held, however, upon a small arbor or pin E, which holds the size of the loop at the end of the work against any tendency for it to close flat when the dies are pressed against it. This pin is carried in a holder F which is mounted upon a spring plunger G placed vertically in the back of the die shoe so that it can move freely when released by the dies.

The operator places the work over this pin and the upper die, in descending, carries the work and the support F down until the bend is

completed by the squeezing of the piece between the dies; then on the upstroke, the spring-actuated device lifts the work clear and it is removed from the end of the short pin *E*.

While the dies here, as in previous illustrations, are of tool steel, hardened, there are various examples of bending and forming tools where all parts are of machine steel, which very often is not even case hardened. This is, of course, with dies used on small lots of work or where the general conditions of operation are such as to impose little wear upon their surfaces.

A Flat Forming or Curling Job

The tools, Figs. 21 and 22 are for making the piece shown in Fig. 20. This is a triangular part, blanked and formed from $\frac{1}{32}$-in. stock.

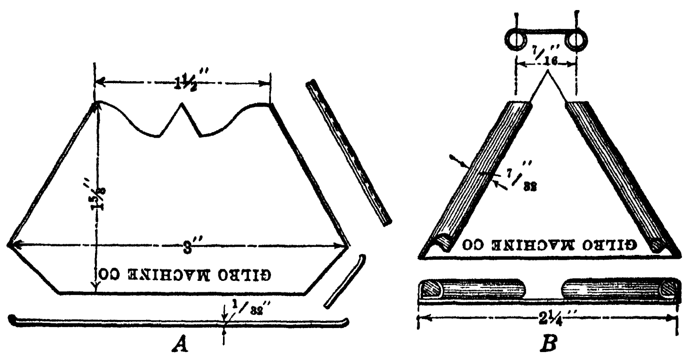


Fig. 20.—The work before and after curling and forming.

It is curled or formed at the edges and one end of each curl is closed by pinching under a punch.

The blanking is done in tools of the progressive order and before the piece is blanked from the strip it is stamped as indicated, on the face. The progressive tools need little in the way of description but there is one feature to which attention should be called:

These blanked parts are to be curled or formed up at the ends as pointed out, and to assure this operation being performed satisfactorily, the edges where the curl is required are bent very slightly, as indicated by the sketch at *A*, Fig. 20. Without this starting edge there would be no assurance that the curl would be started correctly in the second operation dies. So the blanking tools are made with the edge slightly chamfered off from the blanking punch. At first thought it might be expected that there would be difficulty in cutting out the blank with a punch so chamfered on its corners, but in practice no such trouble has arisen. The work comes out of the dies with a clean edge slightly bent up as desired. Probably because the metal is of such light gage, the beveled edge of the

punch acts to "pinch off" the material after it has turned the edge as required.

When the blank is placed in the forming or curling tools, Figs. 21 and 22, it lies flat in the die as seen in the latter view, and the edges are upturned so that when the forming slides or jaws, *J* are forced forward, the metal blank naturally follows up and around the inside of the concaved jaw ends and rolls into a neat curve.

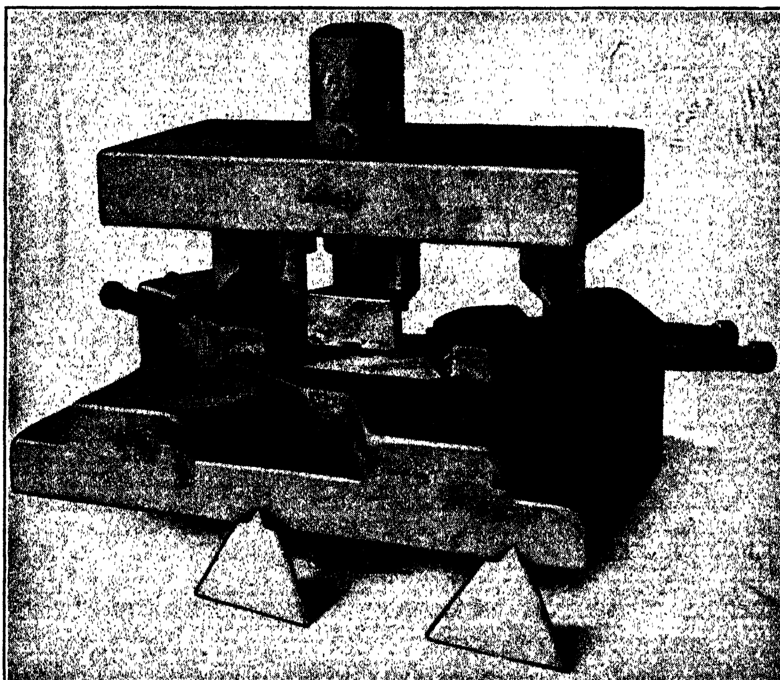


FIG. 21.—The end curling die.

The jaws *J* are actuated by the plungers *K* carried by the punch holder. They are provided with wedge shaped surfaces near their lower ends, and these inclines, after the plunger ends are well down and supported in their guides in the die base, force the sliding jaws *J* forward to do their work. The punch *L* is a spring plunger with a large head which serves to hold the blank in position in the die during the forming operation. The blank rests between the two angular faces of the jaw housings at *M* and a tool steel block fitted in at *N*. At the side of the plunger *L* there are two small punches *O* which are adapted to strike the top of the curl on the work and pinch one end down to the form shown in Fig. 20, *B*. The spring plunger *L* has sufficient movement in its holder to allow the latter to descend for some distance, after the plunger starts, to hold the

blank, and during this continued travel the work is curled up and the ends flattened.

On the up-stroke of the punch holder, the sliding jaws *J* are withdrawn from the work by the action of the springs *P* and the spring plunger *L* releases the finished piece.

The jaws *J* which do the forming are of tool steel, hardened. They slide in obliquely planed seats in the die shoe and are held in position by

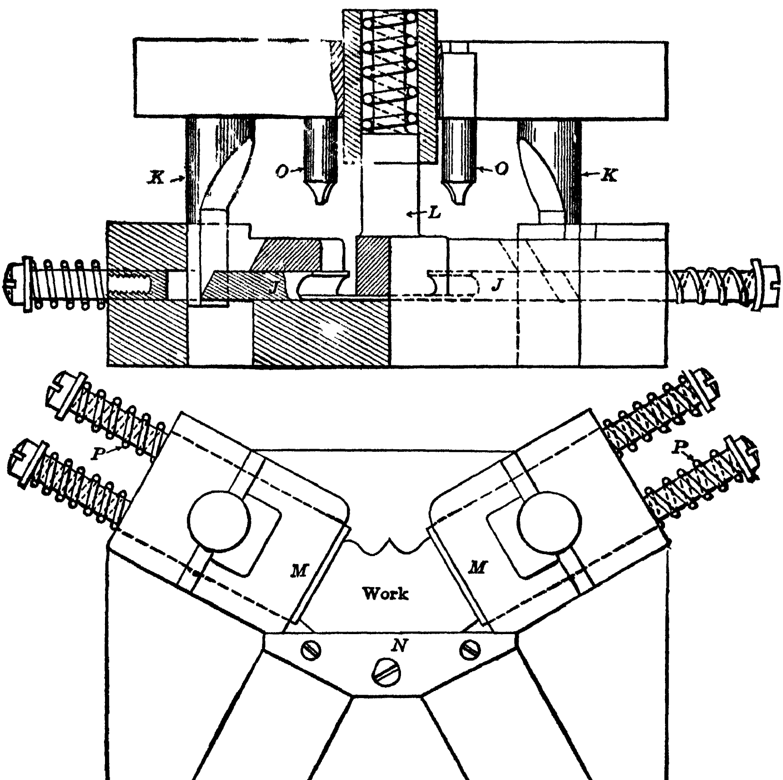


FIG. 22.—Dies shown in Fig. 21.

machine steel cover plates. The beveled plungers *K* which operate the jaws are also of tool steel, hardened.

Spring Forming with Sliding Jaw Dies

These dies with sliding jaws and similar devices for bending up a blank or for forming the ends into the desired form are often known as compound bending or forming tools to distinguish them from the more commonly used plain die with simple bending punch and fixed die jaws. The compound type is frequently employed for such operations as spring bending

of forming and an example of this class of work is presented in Fig. 23 herewith.

This illustration represents the cross section of a die for performing the last operation on the flat spring shown at X, while Y shows the spring as it comes to the die. The operation of the die is as follows: The work is placed on the lower part of the die between small gage pins, which are not shown. The press is tripped; and as the upper part of the die or the punch descends, the ends of the spring are turned up into vertical position by the L-shaped piece A forcing the steel down into the groove cut through the square head plunger B. As the upper half of the die continues to descend, the plunger B is carried down against the action of a coil spring within the

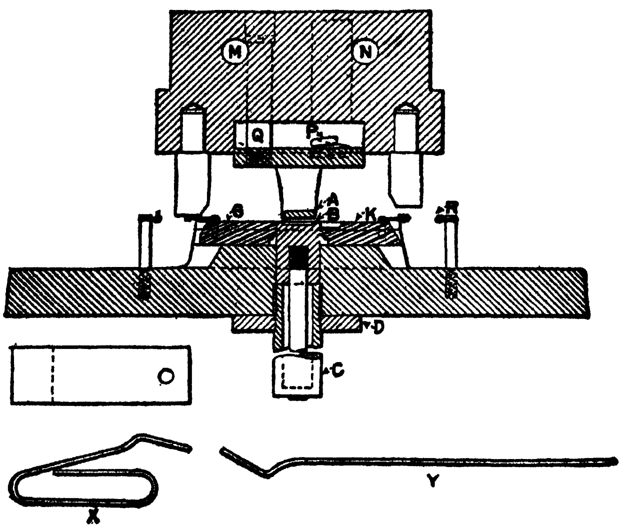


FIG. 23.—Spring forming die.

barrel C. The square steel plate D is threaded to fit the thread on C and is fastened to the cast iron base of the die. The plunger B is forced nearly down to the top of the barrel C when the wedge engages the slide G, which is forced toward the center of the die and thus starts to form that end of the work around A. As the downward motion continues, the other wedge engages the slide K and thus folds over the other end of the work.

While this part of the operation is being done, B is stationary and A is being forced upward against two heavy coil springs, only one of which is shown at P. These springs are located in diagonally opposite corners of the rectangular upper end of the steel part A. In the other two corners are hold-up bolts that also act as guide pins. One of these is shown at Q. As the head of the press ascends, the slides G and K are pulled back against stops by the coil springs R as shown. There are two of these springs on each slide, arranged in the form of a V, to pull on each slide. Bolts pass

through the holes M and N to fasten the upper half of the die to the ram of the press.

Progressive Type of Dies for Bending

As already noted, bending and forming dies are often arranged on the progressive order to allow a series of operations to be accomplished simultaneously in a set of tools. Such operations may include piercing, bending, and blanking; or piercing, cutting off. and curling; etc. Some illustrations follow, these being shown in connection with some simple

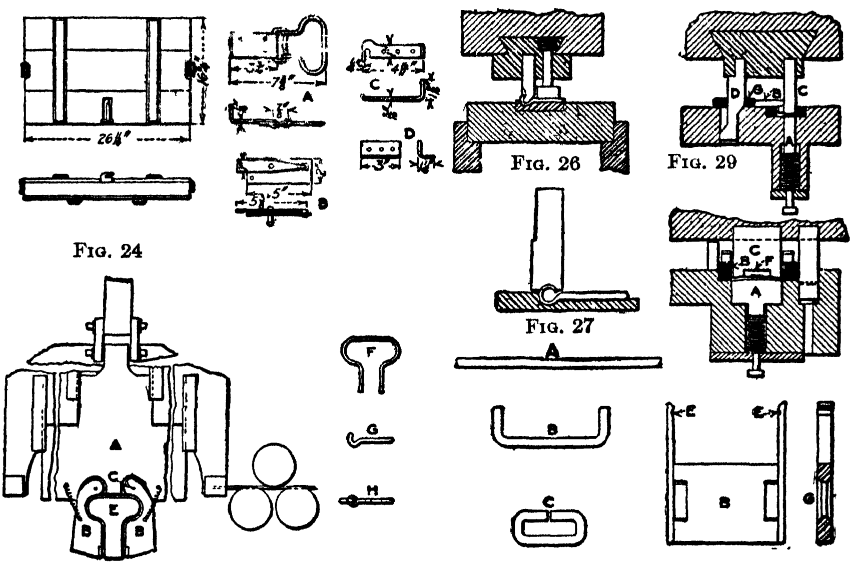


Fig. 24 Fig. 25 Fig. 26 Fig. 27 Fig. 28 Fig. 29 Fig. 30

Figs. 24–30.—Ammunition box and hardware and the tools used.

bending work on parts used in conjunction with the pieces made by the progressive type of dies.

The handle A, Fig. 24, consists of three parts, the wire grip, the wire loop, and the strap for attaching the handle to a box. Beginning with the wire grip there are three essential operations; cutting the blank from the rod, bending the blank to shape for the hand hole, and curling the ends for the attachment of the link.

The sketch, Fig. 25, is a diagram of the press attachment used for the first two operations. The machine used was not a satisfactory one for the purpose but no long stroke press was available so this attachment was devised. The device fastens to the front of the press and is operated by the balance arm; since but little power is required it works satisfactorily. The fixture requires little explanation. As part A descends it comes in contact with the parts BB, causing them to swing about their pivots CC,

forcing the blank to take the shape of the form *E*, also shown at *F*. The return stroke of the press withdraws *BB* allowing the removal of the finished piece and the insertion of a blank ready for the operation to be repeated. Following the bending operation, the ends are curled to receive the link *G*, and lastly closed over the link as shown at *H*.

The method of curling the ends, which are completed in two operations, is illustrated by Figs. 26 and 27. As can be seen in Fig. 26, the handle is placed flat in the die, the ends against a stop while a spring clamp holds it in place. As the punch descends it forces the handle into the grooves in the die thus giving it the required shape, the bend being made, of course, far enough from the ends to leave sufficient material to complete the loop. Following this operation, the link is placed in position and the loop closed with the tools in Fig. 27.

The making of the link or wire loop consists of essentially three operations: cutting off the blank, bending the ends, and curling to complete the loop. These operations are shown in Fig. 28. The rod is sheared to the proper length by a simple operation that requires no explanation. Following shearing, the blank passes to a double punch and die, Fig. 29, where the ends are bent to the form shown at *B*, Fig. 28, thence to the second part of the machine where it is again bent or curled at *C*, thus joining the ends and completing the loop.

The first bending operation leaves the link clinging to the punch or die, and to make certain of its removal and transfer to the next operation, with safety to the operator, the knock-out and transfer devices shown at *A* and *B*, Fig. 29 are utilized. The knock-out is very simple and can be readily understood from the sketch; the transfer device, however, requires a brief explanation:

During the forming of the blank the two wedge-shaped pieces *D* act on the tapered portion *G* of the transfer device *B*, moving it toward the punch until the notches *E*, Fig. 30, grip the link. The return stroke of the press causes the device to move in the opposite direction sufficiently to bring the link into position for the final operation which is performed by the punch *F*, Fig. 29. The action of the punch *F* is similar to that of punch *C* and simply bends the link in the center, joining the two ends and completing the loop.

Making the Strap

The strap which fastens the handle to the box is next in order and its manufacture consists of five operations; punching the screw holes, blanking, preliminary curling to receive the link, final curling, and bending the angle at the end. The stock from which these straps are made, is 2- by $\frac{1}{16}$-in. steel. The first press performs three operations in the order named. At commencement of this series of operations, the strip of steel is pushed

under the stripper in Fig. 31, to a point where the end will just be sheared, and punching and shearing then take place. The end of the strip is then brought up against the top just beyond the curling die and the operations take place in the order already indicated. After the curling operation, the strap is left in the shape at *A*, ready for the closing of the loop. The shape and position of the curling dies are shown at *B*. Immediately following this operation, the curling is completed, joining the loop and strap, and the end of the strap is then bent at a right angle for fastening to the bottom of the box.

Fig. 32 shows the fixture for the final bending operation which connects the strap, loop, and handle. Fig. 33 shows the tools for bending the angle on the end of the strap, these being placed in the same press with

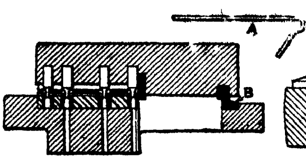


FIG. 31

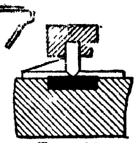
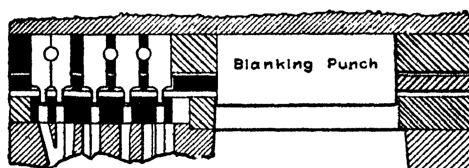


FIG. 33



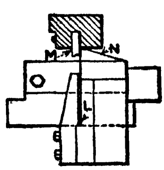


FIG. 32

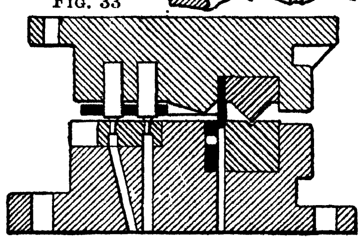


FIG. 34

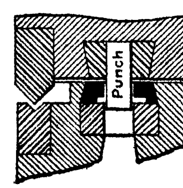


FIG. 35

FIGS. 31–35.—Ammunition box and hardware and the tools used.

those for forming the strap. The fixture in Fig. 32 is used as follows. The long end of the strap is placed upright in the slot *L* and when the punch *M* descends it causes the curved end to bend until it lies close to the body of the strap, thus forming the loop for enclosing the link. During this operation, the loop is held in place by the handle which is laid back over *N*. Bending for the angle requires no explanation, this being performed at the same time as the final curling.

The small angle *D*, Fig. 34, serves to fasten the side of the box securely to the bottom and is made in four operations. These are: punching for screw holes, shearing, counter-sinking, and bending. The punching, shearing and bending operations are similar to those already shown for the handle strap and the counter-sinking is performed in an ordinary drill press. Fig. 34 illustrates the arrangement of the tools in the press for these operations. They are simple and self-explanatory.

The latching device for the cover consists of the latch on the cover *B*, Fig. 24, and a formed hook attached to the bottom of the box. The

construction of the latch requires only very simple operations of punching and shearing for the spring plate, while the portion which engages the hook is forged. The making of the spring plate and latch requires no tools of special interest and need not be described.

The hook used in connection with the latching device is the heaviest work on any of these parts and there are four operations: Punching, blanking, counter-sinking, and bending to form the angle. The finished hook is shown at *C*, Fig. 24. The punching, blanking, and bending operations are, of course, all performed in one operation in a press and the counter-sinking in a drilling machine. Figure 35 shows the arrangement of the tools, including the die for the angle, which is formed at the same time.

Progressive Trimming Die

The progressive dies in Figs. 36, 37, and 38 produce a blank for a lock part by means of trimming operations and then form it and cut it

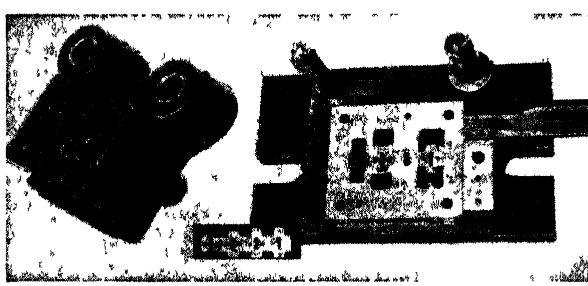


Fig. 36.—Progressive trimming, piercing, forming die, for lock part.

off to required shape at the ends. Principal die-block dimensions are given in Fig. 37, and the piece completed is seen in this drawing. The punches are indicated by the crosshatching in Fig. 38. Both views show the two-step advance between first and second stages (*G* and *H*, Fig. 37) which provides for ample space for the punches which on their downstroke are well housed in the die openings before the cutting edges contact the work.

The first stroke trims out the strip of steel at the sides to form two tapering ears; at the same time two $\frac{3}{64}$-in. holes are pierced, and a rectangular slot pierced in the center, this measuring about $\frac{3}{32}$ by $\frac{7}{16}$ in. As indicated on the die-block plan view, Fig. 37, this cross slot acts as a piloting opening for the following locations of the strip. The third position of the work is over die *H* and locating plus *h* where the ends *I*, Fig. 39, are formed up over the ends of the upper punch to practically a 30-degree angle. The sketch, Fig. 39, is shown to larger scale to bring

out the successive stages of the work to better advantage. A pressure pad of stripper with heavy spring application is carried by the punch head, and all punches fit snugly therein.

In the same position of the work the two small holes are enlarged to $\frac{3}{32}$ in. by forming punches which force the metal around the hole down into a hub projecting $\frac{1}{32}$ in. below the under surface of the blank. Note the hubs drawn down in Fig. 39 at station H. At the same time the punches counter-sink the tops of the holes by means of the shoulders on the punches.

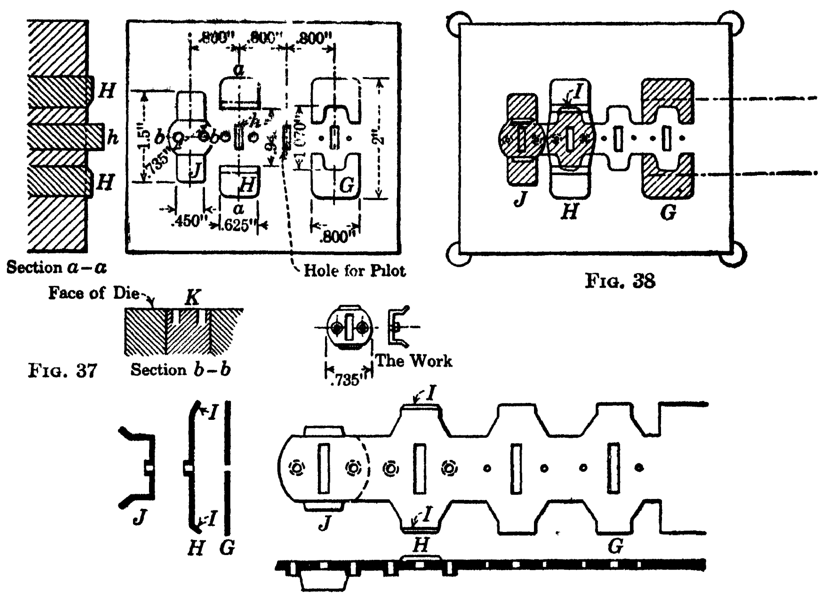


Fig. 37

Fig. 38

Fig. 39

Figs. 37–39.—Details of die and work shown in Fig. 36.

The final stage in these dies is at J, Figs. 37 and 38. This forms the piece into the bent shape at J, Fig. 39, and cuts it off with circular arcs at the sides so that it has an interrupted circular outline. The projecting portions of the punch fold the two sides of the blank into the die, and continued downward movement cuts off the finished piece.

The forming pad at K, Fig. 37, acting against rubber pressure holds the blank until formed and allows further downward movement required for cutting off the finished blank. The blank is stripped by the spring pin in the blanking punch which leaves the work in the die from which it is removed by compressed air piped through the underside of the die. The two holes in the forming pad K are merely clearance holes for the two projecting hubs under the work.

Multi-stage Die for a Forming Job

The dies in Fig. 40 are for manufacturing a U-shaped part used in a cupboard catch. The finished piece is illustrated clearly in Fig. 41, which shows the work about two-thirds actual size. It is made from 0.045-in. steel, Roebling flat wire stock.

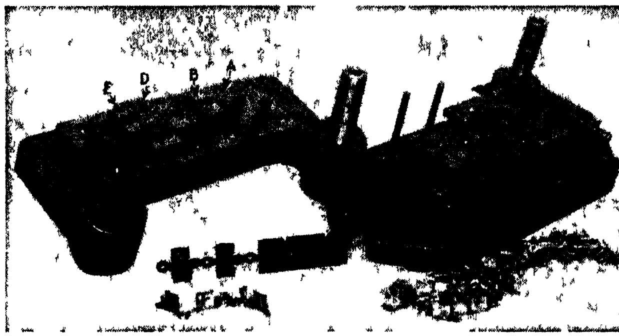


Fig 40 —Dies for a metal catch

The operations in the dies, Fig 40, are as follows: (1) Put in location notch 1, Fig. 42. (2) Pierce four rectangular holes and the square hole 2. (3) Trim out sides, pierce round hole 3, do first-forming on ears 3*a*, and emboss around the square hole. (4) Pierce the two small holes in ears, indent the small depression 4, and finish form the curved edges


Fig 41 —The work made in dies in Fig 40.

of the ears. (5) Bend up ears into U-shape as shown by Fig. 41, and cut off the piece.

In operation, the strip of stock passes under the stripper plate at the right-hand end of the die, Fig. 40, and is located step by step as it feeds through the dies by the stop at the back engaging the edge notches marked "1" in Fig. 42. The position of the piercing punches for perforating the rectangular and square holes is seen in the photograph at *A*, Fig. 40. The trimming dies are at *B*, Fig. 40. These are carried by the upper shoe or punch head with the punch proper in the die shoe as indicated in the simple sketch, Fig. 43. Here the lower tool or punch

is shown with sharply flaring base as at *C* which serves to deflect the trimmed portions of the blank and shoot them out of the dies. The trimming stroke also pierces the small round hole 3, Fig. 42, and as the dies come to bottom position the first forming is done to sink the depressions in the ears at 3*a* and emboss the ring around the square hole. The finish forming of the ears and the piercing 4, Fig. 42 and indenting follow next, and then the work is bent down into the U-shape and cut off by punch *D* and forming dies *E*.

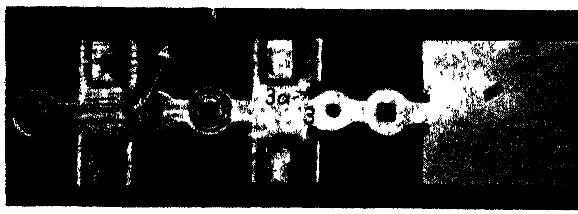


FIG. 42.—Progressive stages in making piece shown in Fig. 41.

An important feature at this point is the ejector for lifting the U-shaped form out of the bending dies. The sketch, Fig. 44, shows the general arrangement in principle without holding to exact scale or including every detail. The forming die is indicated at *E*, the work bent down to U-shape at *F*, the lower die over which the piece is bent is a rectangular member *G*, placed like a bridge between the openings in which the ejector members *K*, *K* are adapted to move up and down with the action of

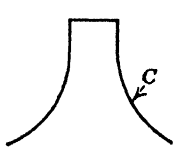


FIG. 43.—Flared trimming tools.

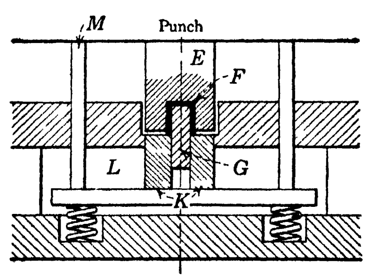


FIG. 44.—Knock-out to clear forming punch.

the press. The bottoms of ejectors *K*, *K* are attached to plate *L*, which is forced upward by spring action. The plate is forced downward by the four pins *M*, *M*, which are located as shown in the photograph, Fig. 40. The purpose of these four pins is to carry the ejectors down ahead of the work while it is being bent down into U-form over the bridge die *G*, Fig. 44. In this manner, the die is cleared in advance of the forming punch, and as soon as the up-stroke begins the U-shaped work is lifted by ejectors *K*, *K* and carried up out of the dies.

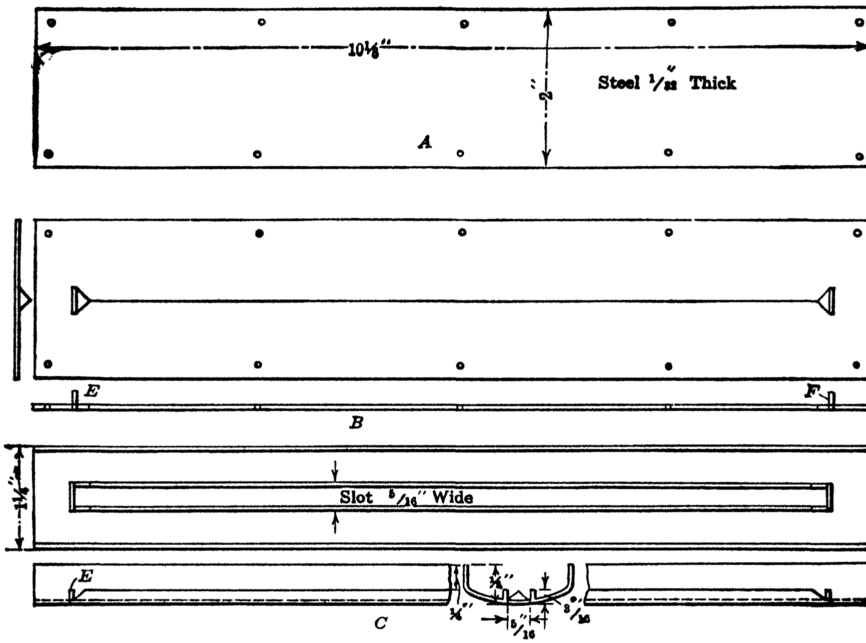


FIG. 45.—Sequence of operation in blanking, slitting, and slotting.

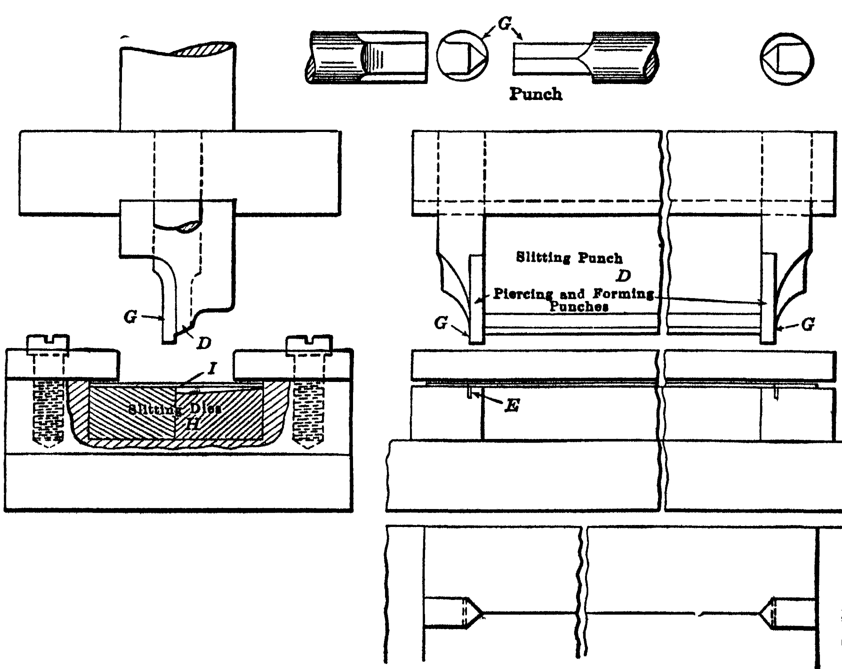


FIG. 46.—Slitting dies.

Application of the Slitting Principle

In connection with the use of bending and forming dies there is now and then a piece of work where an unusual operation is required before the real work of forming can be accomplished. This preparatory operation, as it might be called, consists in cutting a slit with a pair of dies to provide two edges for folding or bending back as in forming a channel or similar opening in a sheet metal member. A case in point is herewith illustrated by the sketches in Fig. 45 where *C* is a machine part formed up to a shallow channel-shaped piece with a slot $\frac{5}{16}$ in. wide nearly the full length.

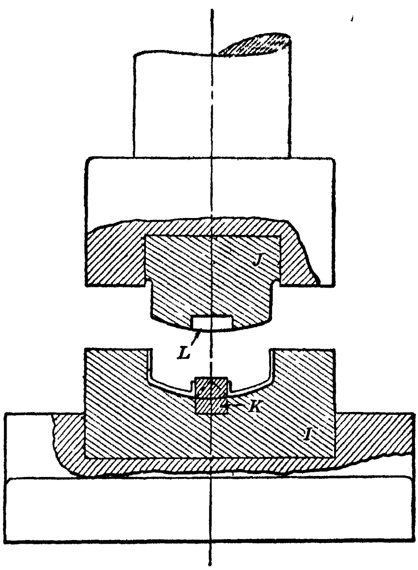


Fig. 47.—End view of forming die.

The blank for this part is shown at *A* with a series of holes pierced around the edge. At *B* is shown the piece with the slit cut along the center line and two small triangular tips formed up at the end of the slit.

The slitting tools are shown by Fig. 46, and referring to their view, the slitting punch proper will be seen at *D* and the piercing and forming punches for the triangular points *E* are located at *G*. These latter punches are made with half-inch round shanks fitted into holes bored in the punch holder. Their sharp V edges are abutted against the ends of the slitting punch *D* and their ends project $\frac{1}{8}$ in. below the edge of that punch to perform their work before the slit is cut.

Referring to the sectional view to the left, the slitting die will be seen at *H*. It is made in two sections, divided along the longitudinal center line, and one side is relieved for a depth of $\frac{1}{16}$ in. as indicated to allow the slitting punch to shear the material past the die edge formed at the shoulder *I*. The slitting punch itself is $\frac{3}{16}$ in. thick back of the cutting edge and has a body thickness of $1\frac{1}{4}$ in. for attachment to the punch holder where it is secured by fillister head screws and dowel pins. The punches and die sections are of tool steel, hardened.

The forming tools are seen in Fig. 47. The construction of the tools will be understood upon referring to the section in Fig. 47. The lower die *I* is of tool steel secured by fillister head screws and dowel pins in a seat in the shoe or base. The upper die *J* is similarly fixed in the punch holder. The lower die is fitted with a tongue-shaped member *K* which

serves as a punch to bend up the material along the edges of the slit, and similarly the punch *I* is grooved at *L* to form a die for this forming operation. Thus, as the blank is forced down into the main forming die *I* its sides are folded up into the channel form and as it nears the bottom of the die the slitted portion is bent up and formed by the punch section *K* and die slot *L*.

The blank is located on the die by gage pins in the face.

A Sectional Construction

The coin register part shown in Fig. 48 is produced from 0.035-in. stock by the tools in Figs. 49 and 50. These are of interest because of

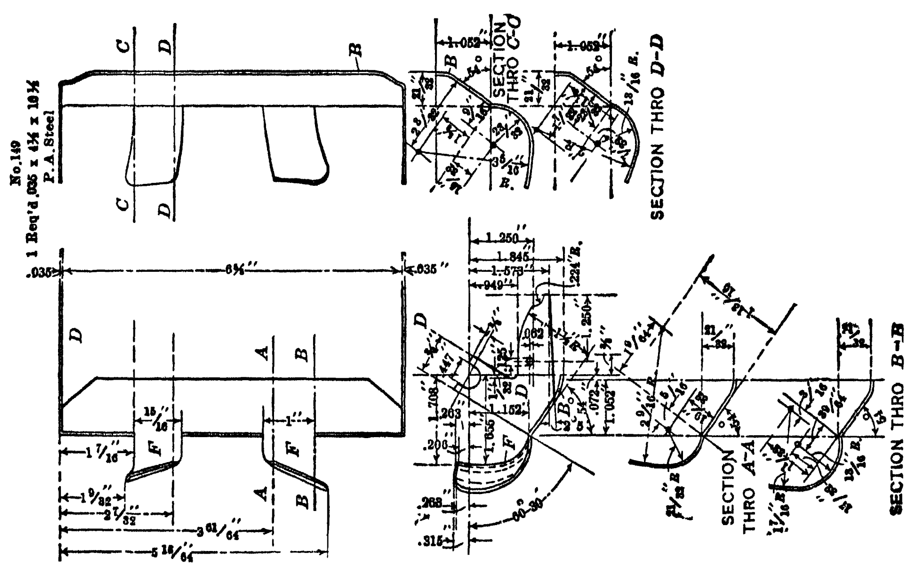


Fig. 48.—An unusual shape to be formed.

the unusual form of the piece and because of the sectional construction of the dies. The blanking tools are represented by Fig. 49.

They consist of the built-up die and punch seen side by side, where the sections of the punch are particularly clear. The die is similarly constructed but the individual parts are obscured by the stripper. The special features of the work are the right-angle bends at each end of the base and the curved deflectors in front which are formed up to a flaring curve diverging from the center outwardly. The flat base is also curved along its edge as indicated in the drawing and the sections there reproduced give the slope of the curves at various points.

The blank is placed for forming, on the pressure pad and knock-out *A*, Fig. 50, which has a locating ledge at the front with a curved face leading up to it to produce the curve along the edge of the work at *B*, Fig. 48.

The end forming die blocks are at *CC* for bending up the wings of the blank at *DD*, Fig 48 At the back of the die are secured two blocks *EE* for forming up the curved deflectors *FF*, Fig 48 The back of the blank rests against stops *GG* (Fig 50) when the work is placed in the dies. As the upper die descends the punch block *A′* forces the blank down into the

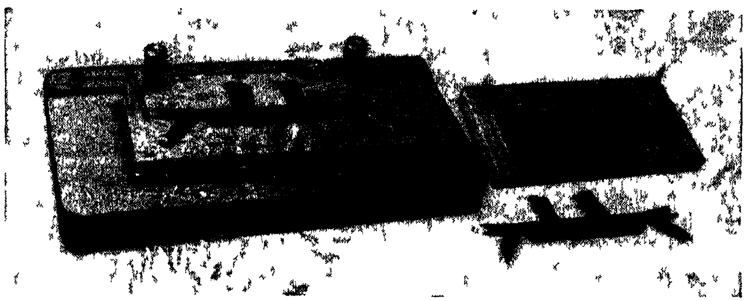


FIG. 49 —Sectional blanking tools

face of the pressure pad *A* and continuing downward, the ends of block *A′* cause the ends of the work to be bent up at right angles against the die blocks *CC*. At the same time the curved end punch blocks *E′E′*, form the ears *F* against the die blocks *E* at the back, and the bent up lip along the front edge of the blank at *B* is formed between the bottom of punch block *A′* and the corresponding curved surface at *A*.

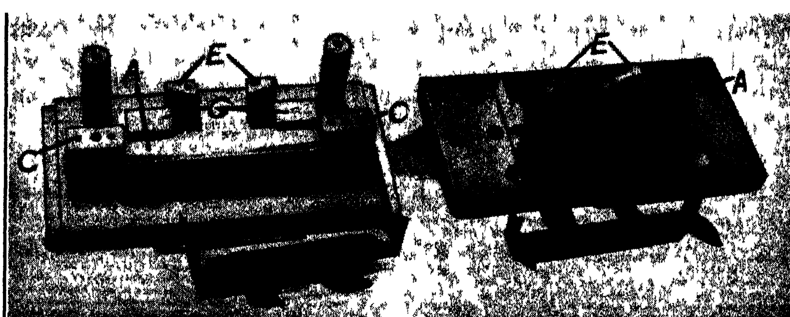


FIG. 50 —The bending and forming dies

When the upper die or punch head ascends, the pressure pad and ejector *A* follow the punch upward and lift the formed work out of the dies.

All parts in the way of punch and die members are of tool steel, hardened, and the punch holder and die shoe are of machine steel. The bolster for the blanking die sections is a large casting planed out lengthwise to form a seat for the various blocks which make up the die as a whole. The stock stop for the material for the blank is of the trigger type and is shown at *S*, Fig. 49. There are two guide pins in this die

base for alining the punch holder, and similarly two pins are used in the forming dies, Fig. 50.

A Word about Curling

In several places certain operations in the line of curling have been shown and a final word may be added at the close of this chapter in reference to this process. It has been pointed out in connection with the operations shown in Fig. 20 that the end of the blank should be made with a slight initial curl to assure its finishing properly when passed through the curling dies. The punch for blanking should therefore be made with the corners taken off to leave a round bend on the blank as at *A*, Fig. 51, so that in the curling dies *B* the ends of the work will follow the concave die form and complete the circle as at *C*.

If the end of the blank is cut off square as at *D* the subsequent curl will be in the form shown at *C* with the end brought down to the body of the blank at *D* but not curled in as it should be. This is overcome by making the blanking punch as stated, with the corners rounded as at *A*.

BENDING AND CURLING THIN SHELLS

We have referred in an earlier chapter to methods of handling thin metal in compound and combination dies and included in that section some illustrations and instructive data regarding the design of tools for this purpose as set forth by a well-known authority in the field, namely, Wallace C. Mills. In the present chapter a few examples are given from the same source in respect to bending and curling thin stock in the form of shells, this following in the way of secondary operation procedure, after the work has been flanked and drawn up into the form of cups. Mr. Mills states that different cases require different construction and that the design of a curling tool, for example, depends upon whether the curl is outward or inward and on the thickness of metal and other conditions.

Burr and Flare Affect Curling

Figure 52 *a* shows the principle of outward curling on the edge of a shell. Outward curling is by far the easiest curling operation, because the direction of burr on the cut edge and the direction of flare on the edge as drawn in a single acting die are away from the curling punch. This condition is favorable to curling. If the shell were blanked and drawn in a double acting die, the burr would be inward toward the curling punch, but as the flare of the edge would be outward, there would still be no difficulty.

The direction of burr is extremely important in curling. If the burr is toward the curling punch, the sharp edge digs into the punch and resist

curling. This difficulty may be overcome by turning the edge, as shown at *b*, in a separate operation.

If the cup is shallow, as shown at *c*, so that the side wall receives support from the end wall of the shell, the inward curl may be made in thin metal without previous turning of the edge. But if the shell is deep, view *d*, the edge must be turned in a previous operation and the inside wall of the shell must be supported to prevent collapse of the side walls. At *d* the work is supported on the outside by a pocket, or nest, in which it rests and on the inside by a expanding punch.

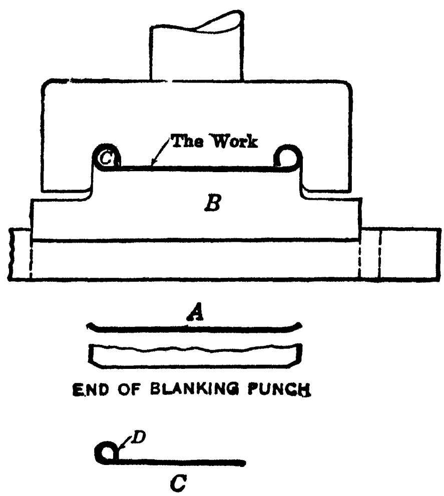


FIG. 51.—Curling operation.

When the curl is on the interior of the work, as shown in Fig. 53, instead of on the periphery, the conditions for curling are different. Inward curling on an interior flange is the easiest, because the direction of flare is inward, as shown at *a*. Outward curling on an interior flange is more difficult, because the stock is apt to crack; so the edge must be cut clean and not ragged.

When the curling groove in the tool is too large, the curl forms, view *b*, to its own smaller diameter. The groove in the curling tool and the curl should therefore be the same diameter, which depends on the thickness of the stock. Curls for stock 0.010 in. in thickness are usually about $\frac{1}{16}$ or $\frac{5}{64}$ in. in diameter, and for 0.018-in. stock about $\frac{1}{8}$ or $\frac{3}{16}$ in.

Figure 54 shows a die for curling a can cover with an outward curl. The die is built as outlined in Fig. 52 *a*, so that the direction of burr and flare of the cut edge are favorable for curling. The work is supported on the outside by a pocket in the die and on the inside by the heel of the curling punch which enters the shell deeply. The curling punch of oil-

hardening steel, 56 to 58 Rockwell C, is made smooth and without undercut. Design details are

1. The curling groove is in the punch instead of the die. As this allows scrap to drop from the curling punch, there is less chance of

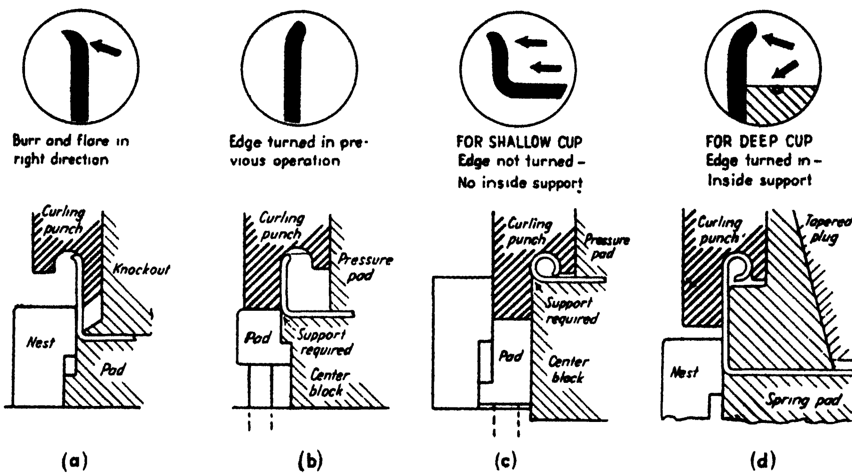


FIG. 52.—Shell edges may be curled by pressing or rolling. Direction of burr and flare affects curling and may require turning the edge inward in a separate operation to avoid gouging into the curling tool.

damaging the die. This construction also permits work to be fed to the die with the open end up, which is the easier way for the operator.

2. Design details for the preferred type of knockout show that it strips the work from the punch and a spring pin then pushes the work from the knockout in case of adhesion from the oil film. The knockout is spring-

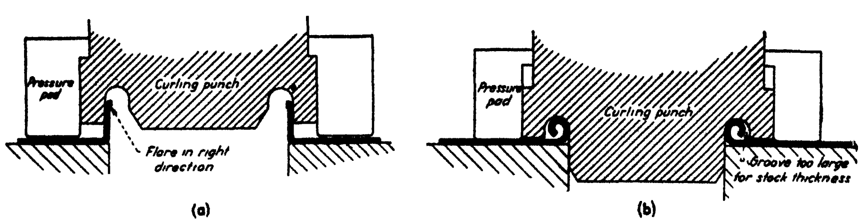


FIG. 53.—Inward curling (*a*) on an interior flange is easier than outward curling (*b*) because the stock is less likely to crack. For either, the groove size depends on the stock thickness.

counterbalanced, so the work will not be knocked out prematurely when picked up by the punch. Two air holes are provided in both punch and die.

3. The design provides accessibility for driving the work from the die in case of jamming and for adjusting the spring tension or replacing broken springs. A lifting plate in the pocket of the die is held up by pins

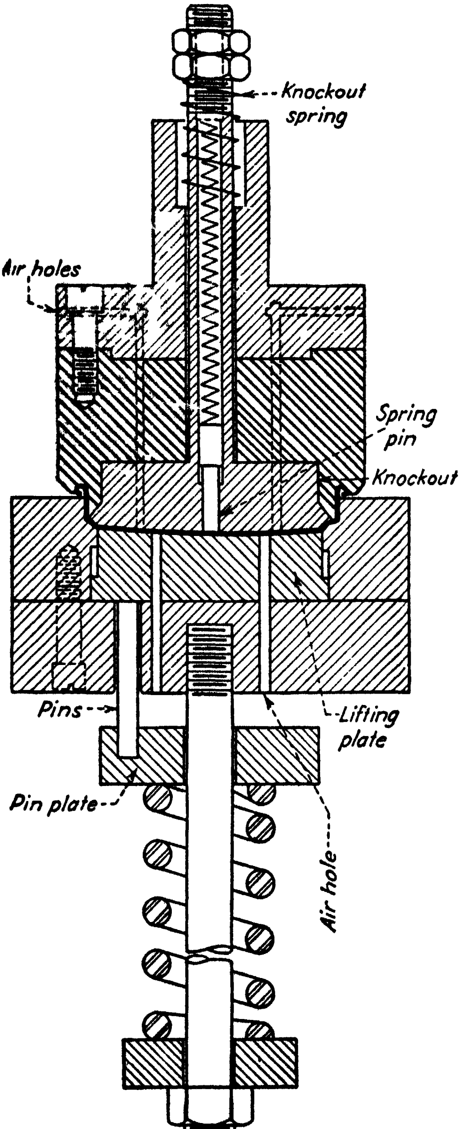


FIG. 54.—Second-operation die forms an outward curl on exterior flange of can cover. Grooving the punch permits feeding the formed cover open end up.

that extend through the die to a pin plate, which may be driven upward to remove jammed work from the die. The pin-plate spring can be adjusted for tension or easily replaced if it breaks. If the lifting mechanism were inside of the die, it would be far less accessible.

Figure 55 shows a die for inside curling of a deep shell wherein the

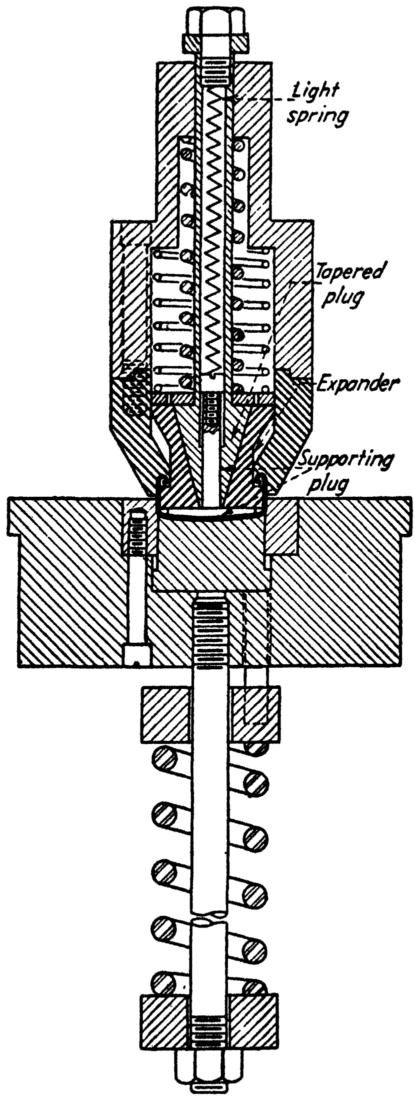


FIG. 55.—Inward curling of deep shell requires inside support from an expander opened by taper plug and collapsed by spring pressure, forcing it against outer tapered surface.

curl is spaced away from the bottom of the shell as in Fig. 52*d*. The curl has been started inward in another operation, and inside expanding support is necessary. The outside of the shell is supported in a pocket in the die.

The expander opens for inside support before the curling punch engages the work. It is opened by a tapered plug backed up by a heavy

spring that yields to provide dwell for holding the expander open while the curling punch descends. The spring is a safety device also, in case two shells are fed into the die at the same time. The expander slides on the top surface of a supporting plug, the lower surface of which is domed to fit the work.

On the upstroke of the press, the curling punch rises first to clear the work, then the expander collapses as a light coil spring forces it downward against tapered surfaces on the inside of the punch. The work is stripped by the supporting plug as it is forced down by a central spring.

The above illustrations and description of press tools for bending and curling thin shells are but a few of the many details in design and construction covered by Wallace C. Mills in his material relating to press tools for working thin stock.

CHAPTER XIV

FURTHER BENDING AND FORMING APPLICATIONS

This second chapter on bending and forming tools and operations includes not only a number of miscellaneous dies for this general class of work but also is arranged to cover certain applications of bending and forming and allied processes to the manufacture of specific lines of parts as used in typewriters, calculating machines, electric elements, automatic registers, etc. In this connection the use of bending and forming dies is shown in different instances in conjunction with allied tools for sequence of manufacture, such tools including, naturally, piercing, blanking, slitting and other types of press tools.

The arrangement of this chapter also gives a further opportunity for illustrating a variety of press tools which, while falling within some one or more of the general classes already described under preceding chapter heads, have, nevertheless, certain features that are peculiar to themselves and justify a description in the present section of this book.

FORMING JOB

The dies in Fig. 56 are a set of wedge-actuated tools for forming a narrow strip of brass into a U-shaped channel. The strip is cut off and

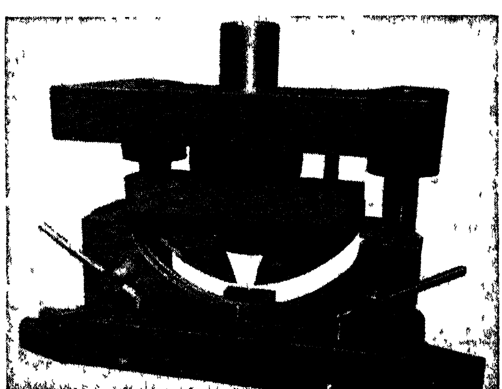


FIG. 56.—Dies for a circular-shaped channel.

bent to an arc of a circle before placing in these forming dies. The upper dies are a pair of curved blades with a guide at their upper edges adapted to travel laterally in a slide mounted under the punch head. The lower die is a semi-circular seat with U-shaped groove or channel along its

face. The two sliding punch members are connected by springs to tend always to draw together except when actuated by the wedge at the center.

When the punch descends, the first effect is to start the U-shape in the brass strip at about the center; then the wedge comes into play and spreads the upper dies apart and forces them into the work all along its length, thus having a sort of drawing action at the same time that they are producing the U-channel. Thus a smooth job is obtained free from wrinkles and accurate in shape throughout its entire length.

The two small handles at the ends of the die block are connected with eccentric pins fitting crosswise into holes bored just under the U-shape in the die. These pins are operated to rotate the eccentrics sufficiently to lift the formed work out of the channel in the die. The length of the work handled in these dies is 12 in. The strip is 1 in. wide, of 20-gage metal.

Progressive Dies for Several Operations

The progressive dies, Fig. 57, are three-stage and the sequence of operations is indicated by the strip of stock shown between the dies.

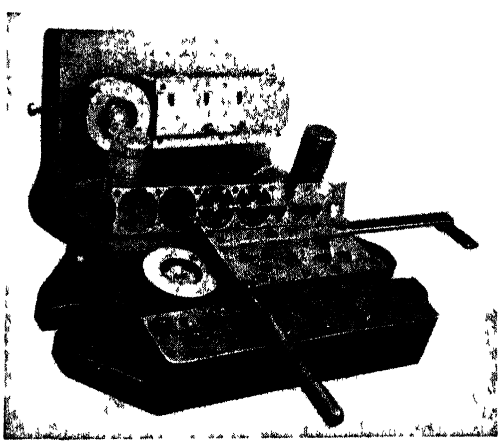


Fig. 57.—Progressive piercing, swaging, and bending die.

The arms of the blanks are narrow, and to avoid breaking them piercing out the metal between them is divided into two cuts. In the first stage, three openings are pierced; the stock is then advanced a distance equal to two blanks; and a second series of three openings is pierced completing the outlining of the six arms. It should be noted that the stock advances a double distance at each stroke. This enables the dies to be spaced a reasonable distance apart with advantages in additional strength and convenience in making, and it allows the stock to be used on the second run with only a hair-line waste between blanks.

The stock strip with the six arms formed by piercing feeds for the next position over the swaging and blanking die at the left end. The locating is by means of the small pierced hole at the upper edge of the strip. The pilot pin for the hole is shown at the right side of the blanking die. Two blanks are shown lying on the lower face of the die block. These will be seen to be swaged out to considerable width of arm. The material is brass about $\frac{3}{64}$ in. thick. The swaging punch upon striking the narrow armed blank swages out the arms to about $\frac{1}{8}$ in. in width, as in Fig. 58, and toughens the metal. The blanking tools on the punch head cut out the blank, form over the outer ends of the arms into the channel in the lower die, and the swaging is accomplished at the same time. The stripper on the upper blanking die is spring actuated to clear the stock from the tools. The inside knock-out for this die is positively actuated by means of a link connecting the two screws at the left side of the die shoes. Similarly the piercing punches at the right are provided with close-fitting stripper plate which acts as a pressure pad for retaining the strip of brass upon the face of the dies.

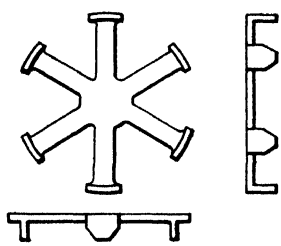


FIG. 58.—Blank after swaging and forming.

The handle at the front of the shoe is an indicator to show if the stock may happen to be improperly located. Unless the stock drops over the locating pin in the forming and swaging die, this handle on the top of the stock cannot drop, and its position shows that the stock is not in position.

This brass piece is later formed and bent into a cup form which holds a rubber seat and forms a quick-acting valve-stem cap.

Blanking, Piercing, and Forming Tools for Typewriter Work

The tools that follow are used in the manufacture of a sheet metal member, known as a universal bar, for a typewriter.

This part is $9\frac{3}{8}$ in. long and is bent up to a quarter circle of $5\frac{3}{8}$-in. radius, as shown in Fig. 59. It has three lugs or arms projecting from the lower edge, which are offset in the blanks and then bent around at right angles to the body of the bar itself. It is made from sheet steel stock 0.040 in. thick, and one piece is required for each typewriter.

Figures 60 and 61 illustrate the blanking tools used in the production of these sheet metal parts. The die is of simple construction, and the punch is of a form requiring little explanation in detail. However, the length in proportion to the width of the projecting portions that form the lugs on the blanks is such that a considerable degree of care and judgment is necessary in machining and hardening these tools in order

to prevent a degree of deformation which would make the punch work improperly in the die. Both punch and die are mounted upon heavy blocks, the bolster for the die being of the standard form used in the factory for a large share of the press tools.

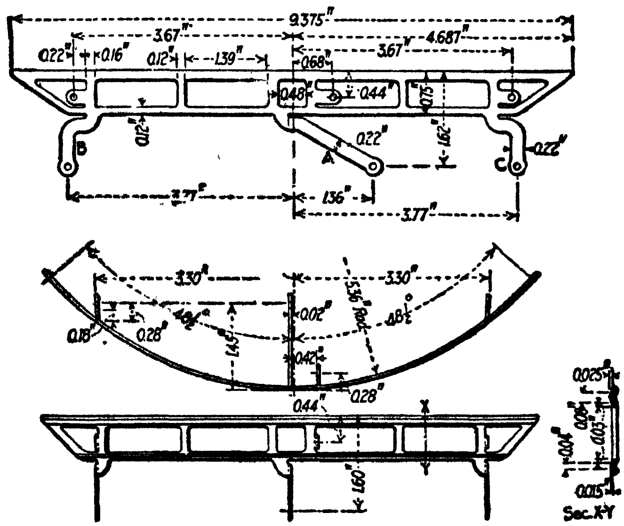


Fig. 59.—Details of universal bar for typewriter.

The proportions of the die proper will be seen from Fig. 60, which shows the layout as indicated by the opening in the stripper and also the width of the stock guide slot in the underside of the stripper. The dotted lines in the top of the plate show that the width of the guide is sufficient

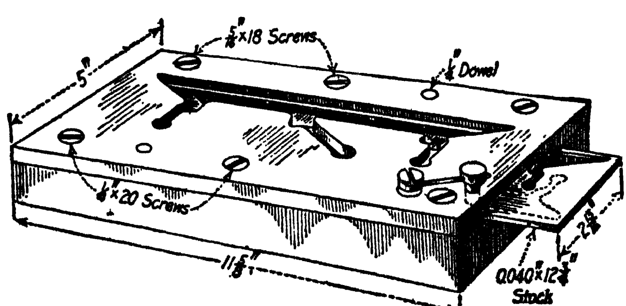


Fig. 60.—The blanking die.

to admit stock wide enough for two rows of blanks, so that the material is reversed for the second passage through the press and there is very little waste along the edges of the strip of stock or between the projecting lugs.

The second die, Fig. 62, is used for punching out the seven openings. In this process a greater portion of the material is cut away. The work is shown at the front of the die. It will be noticed that there are also six

round pierced holes in the lugs. As a matter of fact, this piercing operation is performed in a subsequent process, the blank being shown here in this condition to indicate its appearance before twisting of the lugs occurs.

These dies, like the blanking tools shown, are simple in construction, although they have been laid out and finished with great care to assure satisfactory operation under the punch press. In working material of this thickness, where such narrow portions of the stock are left as are indicated in the illustration, it is important that the material shall have no opportunity for creeping under the punching action of the tools. Otherwise, the

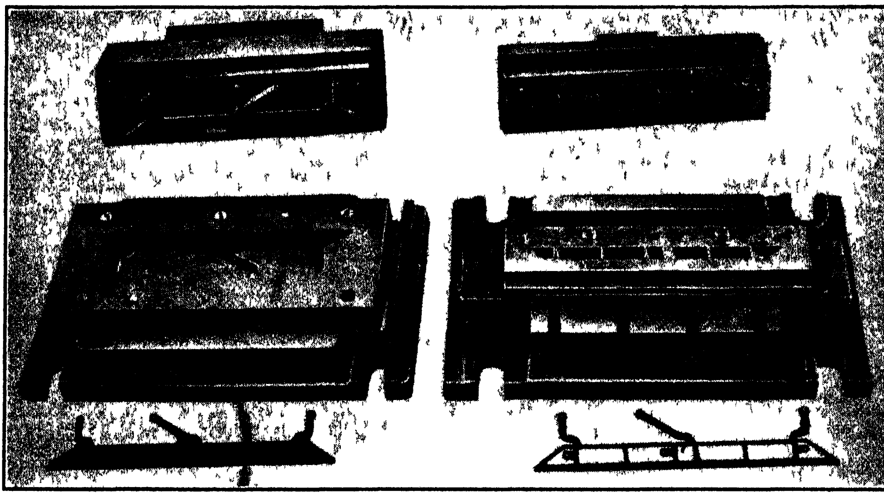


FIG 61 —The blanking tools FIG 62 —Dies for second operation

edges become deformed, the inner openings formed by punching out the stock become twisted, and the job is generally unsatisfactory.

PIERCING SIX HOLES AT ONCE

Referring to Fig. 63, the press tools at the left perform the operation of piercing the six holes in the blank. Here, a sectional construction is used, as indicated. The work is nested under the stripper plate, against suitable end stops and back stops, and is thus retained against movement during the down-stroke of the punch. The latter has a block that is provided with corner posts, thus making a pillar-die construction. As will be seen, the small piercing punches are all carried in sockets sufficiently large to assure stability of the punches and prevent their deflection under the action of piercing this 0.040-in. piece of stock.

Each of the punch members as shown is fastened securely to the block by fillister head screws and an adequate number of dowels, while the holders for the piercing punches are located outside of the punches proper

in holes laid out, and accurately indicated and bored in correct positions on the face plate of a lathe.

The tools at the center in Fig. 63 are for forming up the blank to the arc of a circle and bending down the middle lug or arm nearly halfway to its right-angle position to the body proper. For this operation the work is nested against a stop at one end. The punch in descending with its curved lower contact face forms the blank down into the curved seat on the top of the die, the projecting hub or pilot at the middle of the punch engaging with the square opening at the middle of the length of the work, thus preventing the work from traveling to either the right or the left. Looking closely at Fig. 63, it will be seen that there are stop lugs at both the back and the front of the die to make of the latter a suitable nest in

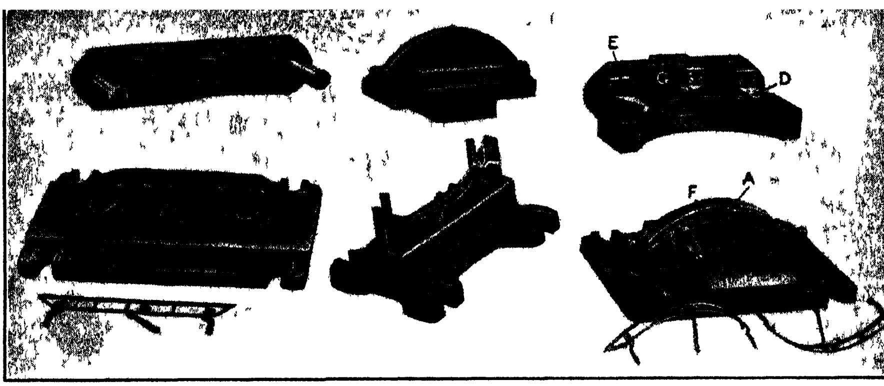


FIG. 63.—Dies for forming the universal bar

which the straight blank will rest securely during the down-stroke of the press, under which it is transformed into the curved article.

At this same setting the two grooves, or beads, running longitudinally the full length of the work are formed up to stiffen the job so that, when bent to the arc of the circle, there will be little likelihood of its being twisted or deflected in action. The stiffening ribs, although shallow, are sufficiently deep to add materially to the strength of the parts and greatly increase its resistance to any forces tending to open the arc out toward a straight line or to twist the curved portion about its major axis. The use of ribs in this way forms a convenient method of strengthening sheet metal work without increasing the weight and adds practically nothing to the cost of manufacture, as the forming of the grooves, which also form the beads, or ribs, on the opposite side, is done at the same stroke of the press as the body of the piece is bent to the arc of the circle and the central lug bent halfway down.

The tools at the right, Fig. 63, are the most interesting of the group in this view, and details will be seen in Fig. 64. It will be noticed that

here the work is nested upon the convex face of the lower die, and on this die block it rests between a pair of pins at the back and two adjustable stop screws at the front. Midway of the width of the die will be seen a vertical offset portion *F* that forms the bending corner over which the middle lug *A*, Fig. 59, is bent around to a true right angle to the tangent line to the universal bar. The lugs at either end, *B* and *C*, Fig. 59, are bent down to a position parallel to the central lug *A* by the two punch members attached at the right- and left-hand sides of the punch block.

Referring again to Fig. 63, it will be seen that the concave block *F* is arranged to act as a pressure pad to hold the blank temporarily during the descent of the press ram, while the punch members *D*, *E*, and *G* fold

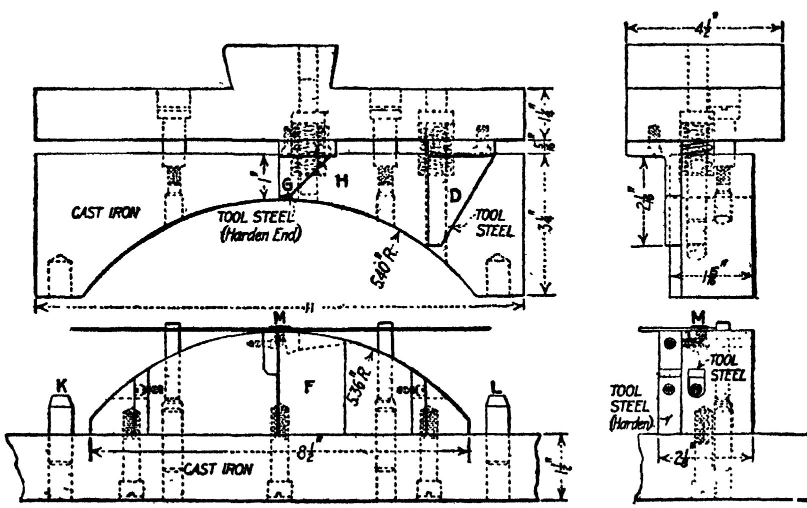


FIG. 64.—Forming die for universal bar.

down the three ears or lugs to the right-angle position. The movement necessary after the pressure block seizes the work is about ⅜ in., and this is allowed for by the compression springs seated between the block *H* and the main punch block, as shown in Fig. 64.

It should be noticed that on the down stroke of the press the first thing that happens is for this pressure pad *H* to drop over the pilot pins *KL*, so that here again a sub-press form of action is obtained in that at the moment of operating upon the blank the punch and die are piloted and guided together by the pillars, or pins, at either end.

The two punch members *D* and *E*, only one of which is shown in Fig. 64, but both of which are clearly visible in Fig. 63, are in the form of angles with stiff uprights and bases, the latter having two substantial screws and a pair of dowels, by which each part is secured to the punch block.

Similarly, the central bending punch G, Fig. 64, is made with a right-angle base and secured by a pair of screws and dowels. This construction enables the part to be fitted up to the work conveniently and to be replaced in case any part should wear out or give way.

The position of the work endwise upon the lower blank when nested for the downward stroke of the press is positively secured against possible end thrust in either direction. due to the lateral pressure of the bending punches D and E by the pilot M. Upon the up-stroke of the press the work is prevented from lifting with the die, due to the binding pressure between the inner faces of the bending punches D and E by a shedder operating between these punches and acting downward upon the work and holding it upon the convex upper base of the lower die.

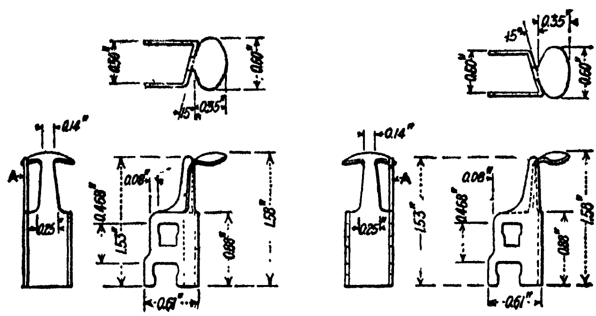


FIG. 65 FIG. 66
FIGS. 65–66.—The two margin stops.

Operations on a Margin Stop

The margin stop on the same typewriter is made in the form illustrated in Figs. 65 and 66, which show both the right- and left-hand stops. It will be seen from the drawing that this piece is of sheet stock formed up to box shape with a clip at the top, by which it may be lifted and moved along from one notch to another on the stop bar. These pieces have an opposite working side for the right- and the left-hand stop respectively, and for the projecting lugs at A, which constitute the stop proper and which engage the corresponding member on the carriage, thus determining the length of the travel of the carriage in either direction. The material for these stops is sheet steel, 0.040 in. thick, and the size of the blank punched out prior to bending is approximately 2 in. wide by $2\frac{1}{4}$ in. long.

The first operation in the punch press is performed with the tools shown in Fig. 67, illustrating the proportions of the punch and die with which the notches at the top and the bottom of the stops are cut out, and a rectangular hole is pierced near one edge.

Blanking Die Arranged to Save Stock

The stock is passed through the die twice, being reversed for the second run, so that the blank which is considerably narrower at the top

than at the bottom, is shown reversed on the second run of the material through the dies and points the other way from its position in the first run. This means that very little material is wasted between adjacent blanks, as compared with the waste that would occur if the material was run through only once. With the broad faces of the blank brought closely

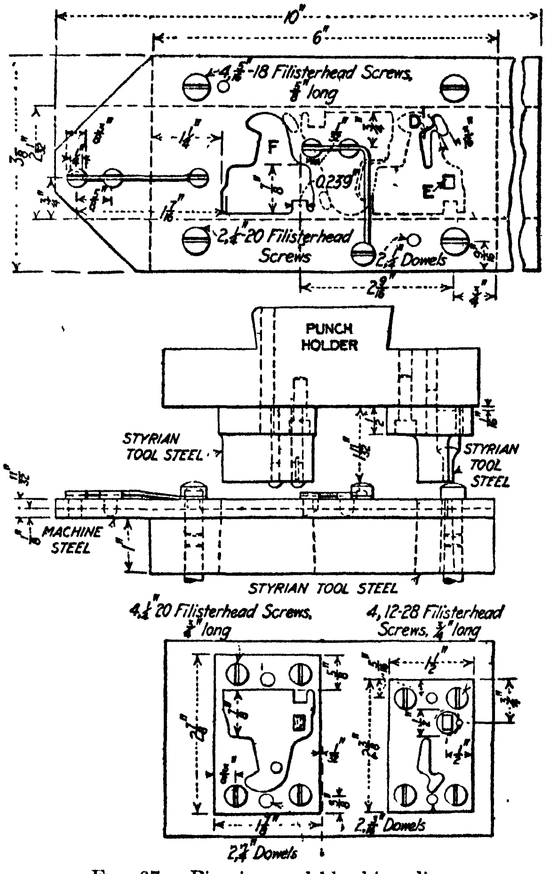


FIG. 67.—Piercing and blanking die.

together instead of leaving them far enough apart to allow the narrow top to fit in between on the second run, much stock would be wasted.

Figure 67 shows the construction of the tools clearly. The strip of metal feeding first under the punches, is notched by the irregular-outline punch *D* and pierced by the square punch *E*. It then advances under the blanking punch *F* where the end of the stock is stopped by the spring stop pin distinctly shown in the drawing. At the next stroke of the press the blanking punch cuts out the blank, the pins in the punch locating the stock accurately so that the blanking is done in correct position relative

to the openings cut by the piercing punch. Following this, each downstroke of the press slide finishes a blank.

After the strip has been passed through the dies once it is reversed as stated, and then fed through against another set of stops so that the blank stock left between the openings, punched in the original passage through the dies, is pierced and a second row of blanks cut out. This is indicated by the dotted lines in the plan view, Fig. 67, which shows the manner in which the stock is stopped against the spring plug in its second run through the press.

The Bending Tools

The bending or forming tools are seen in position in Fig. 68. They consist of a simple punch and a die with a gap of the right width to bend

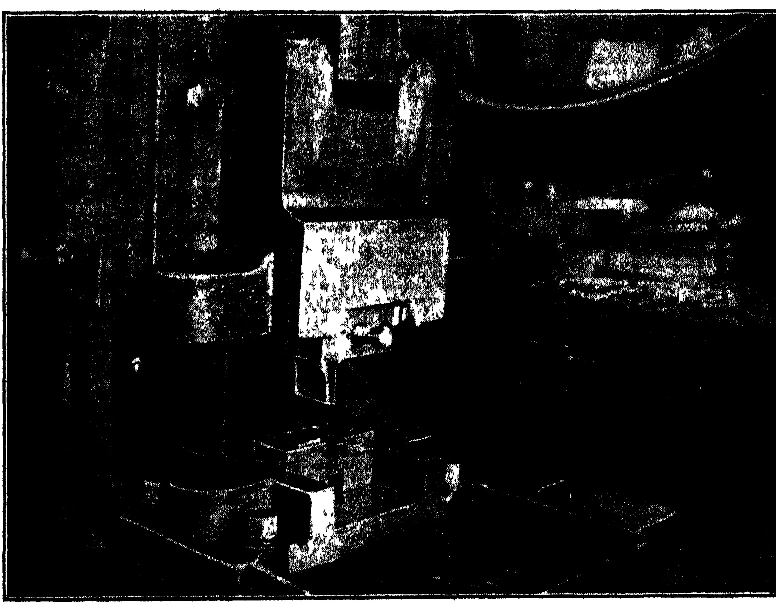


Fig. 68.—The bending tools.

up the ears on the opposite sides of the blank, and a suitable nesting pin over which the blank is located properly before the punch descends. The die carries a shedder which is forced down against the spring action to allow the blank to be bent up on opposite sides. Upon the up-stroke of the press, this shedder forces the formed work upward and out of the tools. The margin stops are then ready for the piercing operation performed by the tools illustrated in Figs. 69 and 70.

It should be noticed that the purpose of these tools is to pierce the plain side of the blank exactly in line with the hole and notch punched in the opposite side in the first operation as already described.

The method of alining these holes in the press tools is shown distinctly by Fig 70 The dies are made right and left hand, and perform exactly the same work, but on opposite sides The work is nested on the punch.

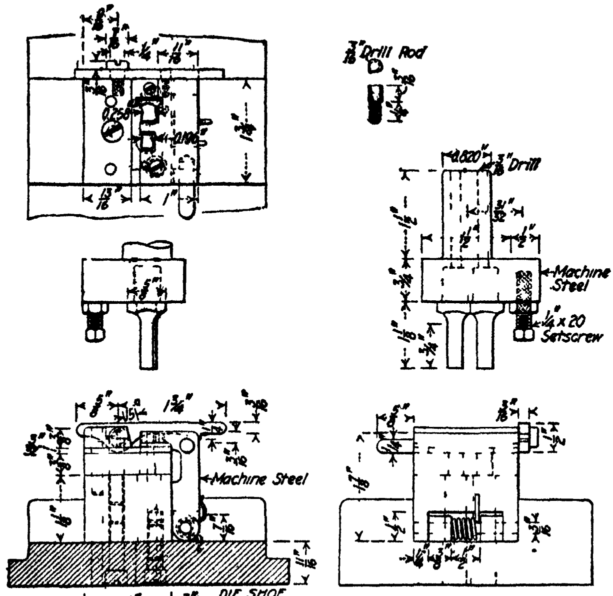


FIG 69 —Details of piercing tools

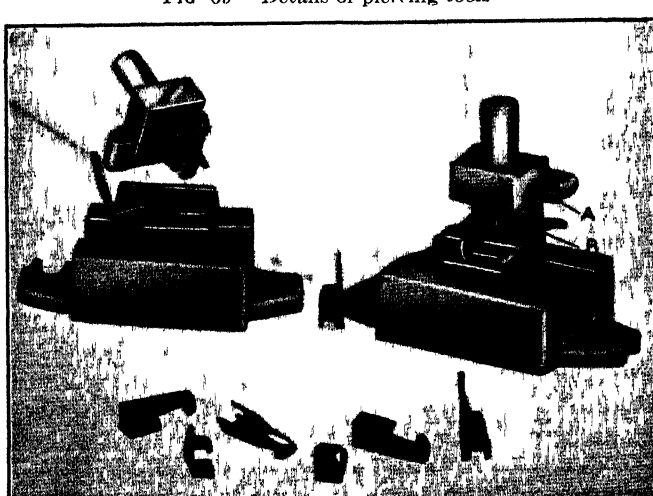


FIG 70 —The press tools

That is, the bent blank, with the holes punched in one side, is slipped up over the punch and when the punch and work descend together, a leaf on the die, which is shown in Fig. 69, snaps shut and, coming between

the upper and lower wings on the formed blank, is designed to serve as a stripper on the up-stroke of the punch. The tools shown at the right of Fig. 70 represent the punch in its lower position and show the method of operating this pivoted stripper. The letters on the drawing will enable this operation to be understood.

As the punch comes down, it strikes the leaf on the stripper, which is swung into place between the two wings of the bent blank. In this position the leaf is locked shut by a beveled-end spring plunger lying horizontally, which snaps outside of the vertical lever on the side and slides along up this upright when the punch ascends.

This arrangement of locking mechanism and releasing device for the stripper is illustrated in Fig 70, where the horizontal spring plunger can be seen at *A*, while the lever against which it acts and rests during its upper stroke is at *B*, which is slightly modified from the construction details shown in Fig. 69, although in principle remaining the same. When the punch has reached the top of its stroke, the spring plunger is out of contact with the lever. The latter then swings outward, allowing the stripper to fly open so as completely to clear the work, which is then removed from the die and another part put in place for piercing. This arrangement forms a safety device for the die and punch; for if the stripper were to swing open during contact of the punch, the latter or some part of the die might be broken.

Bending Tools for Typewriter Springs

The tools in Fig. 71 are for bending a ribbon reverse detent spring for the same typewriter. This spring is shown in the detail, Fig. 72. Fig. 73 gives a plan and side view of the press tools for the work.

The material is tool steel 0.020 in. thick, and the strip stock is $3\frac{1}{8}$ in. wide. Before bending the spring the blank is punched practically the full width of the stock, the blanks being formed crosswise of the strip. The shape of the blank as it appears before bending is an arched or bow form as in Fig. 71. The work is nested between angular guide plates on opposite sides of the die proper. The die itself consists of two movable jaws, which are carried in a longitudinal guide in the die block and slide toward the center when acted upon by the descent of the punch. These jaws are clearly shown in Fig. 73. It will be seen upon inspection of this illustration that the rear ends of the jaws are finished at an angle of 45 degrees as indicated at *AA*. Similar sloping surfaces are provided upon the inner faces of the blocks *BB*. The blocks are attached to the punch carrier above. When the punch comes down, the members *BB* come in contact with dies *AA* and force them inward, causing the blank to hug the punch closely. As a result, when the latter forces the blank down through, the work is pressed tightly against the sloping sides of the

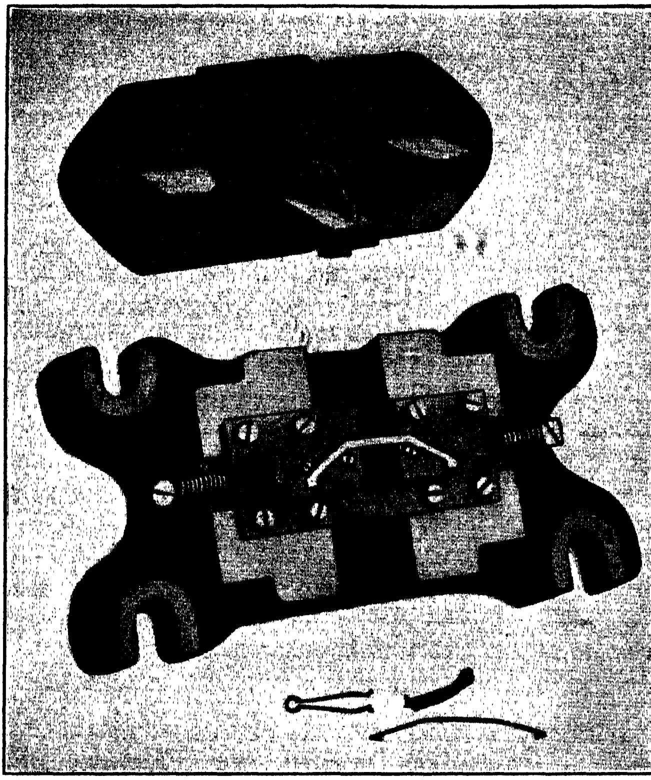


Fig. 71.—Bending tools for a spring.

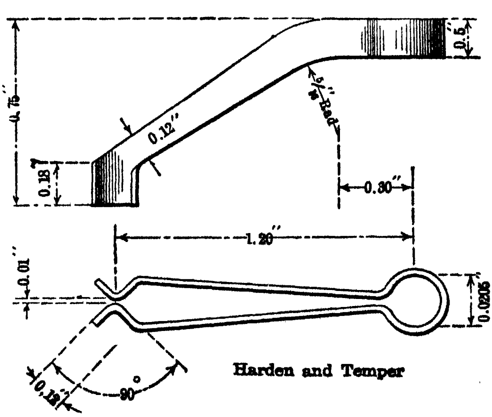


Fig. 72.—Detail of small spring.

parts in contact with it and the V-shaped spring with the flaring opening at the top is formed at one stroke. It should be noted that the open end of the spring is finished to 90 degrees included angle, this being secured by the angular lower face of the punch indicated at *C*.

The partial section in the elevation in Fig. 73 shows a heavy compression spring at *D*. This causes the punch, after it has reached the

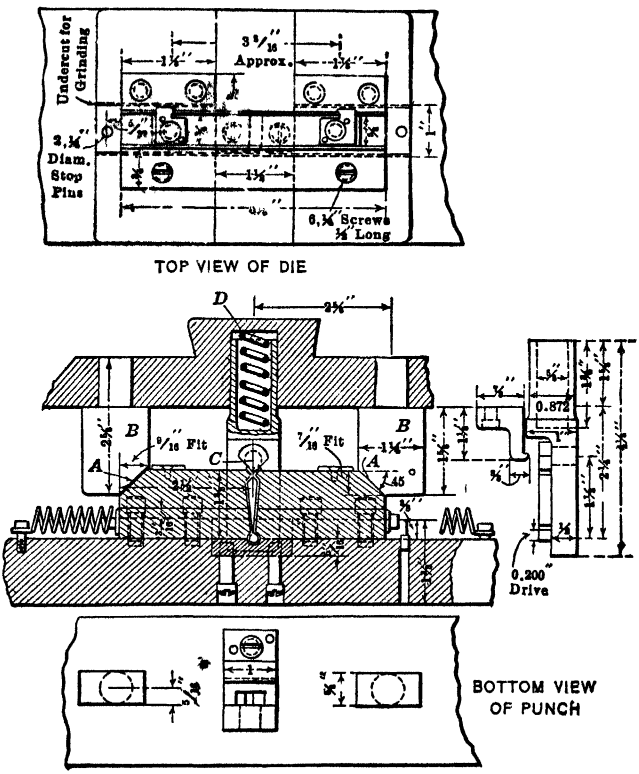


Fig. 73.—Spring forming tools.

bottom of the die, to dwell in that position during the remainder of the downward stroke, while the operating blocks *BB* are carrying the jaws *AA* toward the center to form the spring against the faces of the punch.

On the up-stroke of the press the die jaws are drawn open by the springs shown at each side. The formed flat spring is pulled up out of the die with the punch. From this member it is removed by drawing it off toward the front with the hand.

Dies for Calculating Machine Parts

The following views illustrate some of the press tools for manufacturing parts for a certain model of calculating machine, various other dies for which are shown at different places in this treatise.

The group of parts in Fig. 74 represent the stages in the development of a cover for the carriage of this machine, from the plain steel blank, to the formed, trimmed, and finished article. In this view the sequence is as

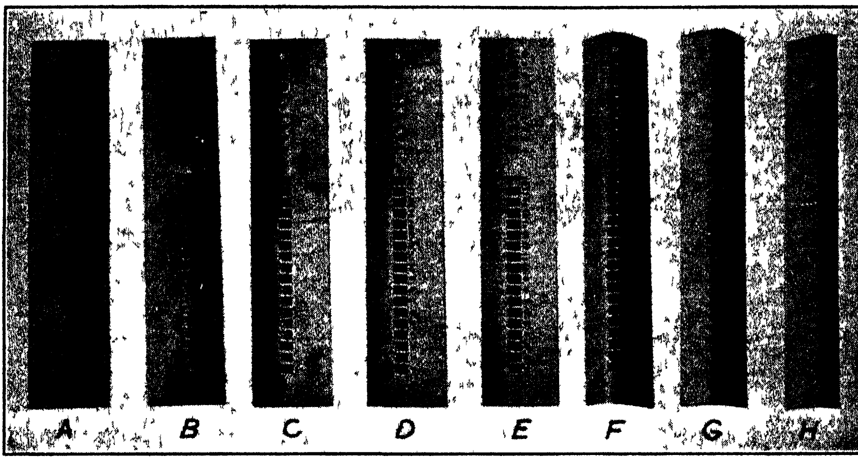


FIG. 74.—Operation in making a calculating machine cover plate.

follows: *A* shows the blank; *B* the blank with the long end pierced; *C* the blank with both ends pierced; *D* the stamping of the numerals on the long end; *E* the stamping complete; *F* the forming of the cover to shape;

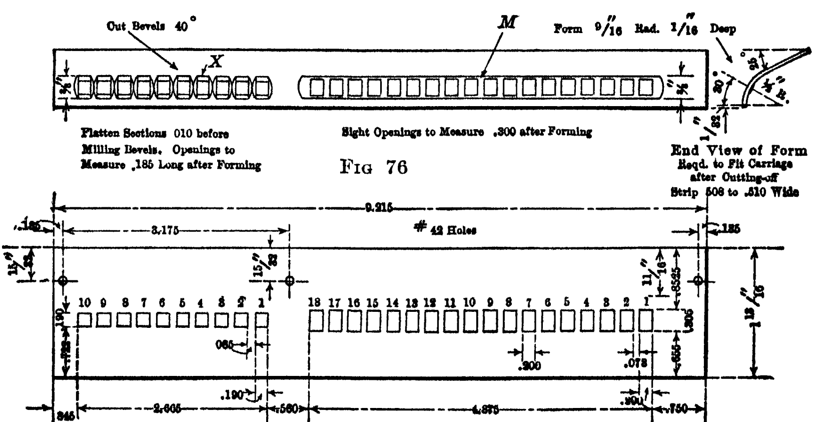


FIG. 75
FIGS. 75–76.—Detail of cover plate.

G the embossing of the bend along the long row of square openings; *H* the cover trimmed to width and thus completed.

Details of the blank are given in the line drawing, Fig. 75, and the piece complete is shown by Fig. 76. Figure 75 shows the cover to be 9.215 in. long over-all, and the blank width to be $1\frac{13}{16}$ in. The stock is

0.040 by 2-in. cold rolled steel. There are 18 rectangular holes pierced from one end and 10 square holes from the other. After the area enclosing the row of 18 openings has been embossed (following the forming operations) the holes appear as in the drawing, Fig. 76.

The Blanking Tools

The die for blanking is of open, sectional construction, in which four separate die blocks are put together, two for each side 9.215 in. long, and

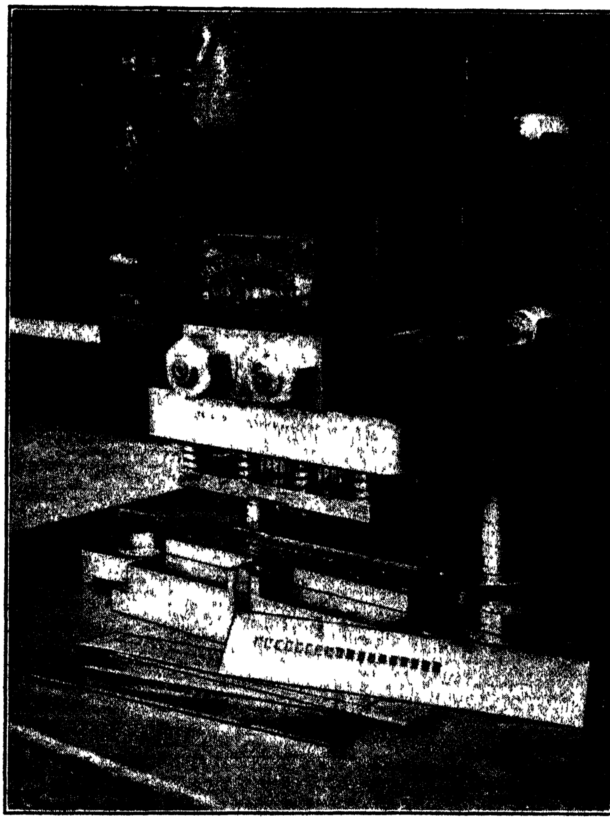


Fig. 77.—Piercing dies in the press.

two for each end $4\frac{7}{16}$ in. long. The die sections are all $1\frac{5}{16}$ in. wide and 1 in. deep. They are of tool steel, hardened, and ground accurately to dimensions. The long sections are secured by four $\frac{3}{8}$-in. screws and three dowels of the same diameter; the short end sections are similarly held to the base by two screws of the same size and two dowel pins.

The inner edges of the die sections are all ground to the usual clearance of $\frac{1}{2}$-degree taper. The method of construction enables the die blocks to be hardened and then ground to size to assure accuracy in all respects.

Also, it permits the sections to be corrected for wear by grinding the contact faces and setting up if at any time this becomes necessary.

The punch is made up of a single block of tool steel hardened and ground to dimensions with all edges square and parallel. It is fastened to its holders by means of four $\frac{3}{8}$-in. fillister head screws and two dowel pins.

The stripper is $\frac{3}{8}$ in. thick and is mounted on guide strips $\frac{5}{32}$ in. thick to allow the stock to pass through readily. The left end of the opening in the stripper is milled out to provide a $\frac{1}{2}$-in. opening over the stock. This stop is low enough to allow the strip of material to be lifted and passed along to successive positions without difficulty during the operation of the press.

Piercing the Eighteen Holes

The piercing operation in Fig. 77 is the punching of 18 rectangular holes in the long end of the blank. This work is also accomplished with

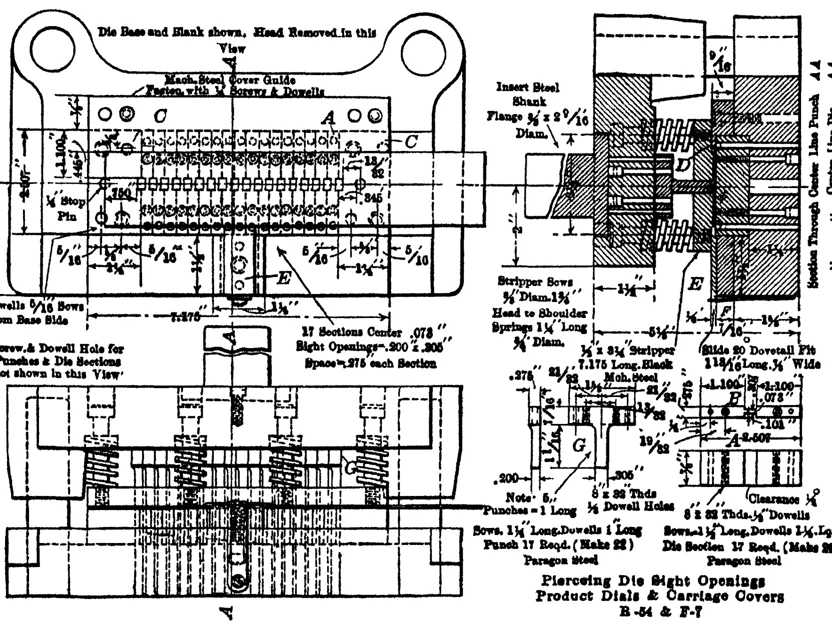


FIG. 78.—Slot piercing die. Sectional construction.

dies of sectional type. The tools are shown in Fig. 78 with all details of construction covered. The holes pierced are known as "sight openings" as they enable the dial readings to be observed through the carriage cover when the calculating machine is in operation.

The blank rests for the piercing operation against a long back stop on the die and an end stop for the left end of the blank. The blank is pressed back against the rear stop surface by a spring-actuated plunger shown at the front of the die. The punch head carries a pressure pad and stripper

through which the individual punches are closely fitted. This stripper is actuated by stiff pressure springs, four in front and four in back, which are coiled from $\frac{1}{8}$-in. square steel. The stripper is connected with the punch holder or head by eight $\frac{5}{16}$-in. fillister head screws adapted to slide up through the counterbored seats in the holder when the latter descends upon the work.

The Die Sections

The die base and punch holder are cast to the form shown in the drawing. The die base is planed out lengthwise to provide a channel in its face 2.507 in. wide by $\frac{3}{8}$ in. deep for the reception of the die sections A, of which there are 17 in all. The die sections are made 0.275 in. wide by $\frac{7}{8}$ in. deep and are 2.507 in. long to fit the seat planed in the base. The die section is made with half the width of opening in each side as at B, and the long dimension of the opening is 0.307, or two thousandths more than the width of the punch for clearance. The punch is, of course, 0.305 in. the same as the slot required in the blank.

With the die section made symmetrical as shown, there is less likelihood of its springing when hardened and it is in some respects easier to construct in the first place as the depth of cut on each side for grinding is only half what it would be if the opening were all from one side.

There are two 8 by 32 thread screw holes in each section and two $\frac{1}{8}$-in. holes for dowel pins. The sections are all ground on the sides to bring them to the uniform width of 0.275 in., and the cutting portion at B is ground $\frac{1}{2}$-degree taper for clearance for the passage of the slugs punched out in operation.

At each end of the series of 17 die sections A, there is a wider block C (measuring $1\frac{1}{4}$ in.) to secure all in place. At the back there is a guide plate of machine steel which overlaps the ends of the die sections as at D. In front is located the dovetailed slide E which is forced forward by the flat spring F to keep the work in contact with the guide at the rear.

The Punches

The individual punches are made in the form represented at G. They are of tool steel, hardened and provided with a T-shaped head ground to a thickness of 0.275 in. and in this case the punch proper is flush with one face of the head so that by placing the punch flat on the magnetic chuck the opposite face may be readily ground to thickness. The same size of screws and dowels is used here as for the die sections. The appearance of the series of punches when assembled on the head is shown by the front elevation in this drawing.

The punch head and die base are provided with 1-in. guide pins for aligning the tools, thus giving them the sub-press type of action.

A second piercing operation, punches the shorter row of holes in the opposite end of the blank. The tools are somewhat like the die in Fig. 78. The work is located on the die base by a square stop pin which enters the last hole in the long row already pierced and so the position is accurately fixed in relation to this first series of openings. The back of the work rests against a guide strip at the rear of the die, and it is pressed lightly but securely against the guide by a spring plunger which bears against the front edge of the blank.

Stamping, Forming, and Embossing

The stamping of the face of the blank with the numerals opposite the two sets of openings is accomplished with the dies in Fig. 79. The two

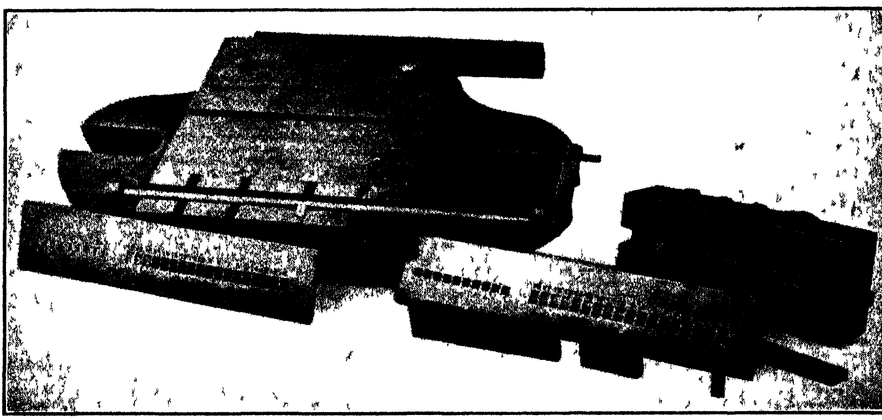


Fig 79 – Stamping tools for marking numerals.

series of stamps are used separately in a holder like that shown to the right in the engraving. The die is a flat steel plate on a cast base, with an adjustable stop rod at the front which is set by turning it in its seat to swing the pin *A* out of the notch in the die plate and allow it to enter the desired stop opening. This rod has a gage arm at the right-hand end which carries a screw point for adjustment to close settings endwise. The work rests against the guide plate at the back of the die with its end located against the stop screw referred to.

The steel stamps for forming the numerals in the work are adapted to be slipped into the punch holder and there secured by the series of screws at the front, and the small end binding screw at the right.

The forming dies, Fig. 80, bend the blank up lengthwise to an angle of 115 degrees included. These dies are simple forming tools which require no description. The work passes from this operation to the embossing dies, Fig. 81, where the surface *M* (Fig. 75) is depressed to form a concave portion extended to include all of the cross bars of

metal left between the square holes by the piercing tools. This effect is clearly shown in Fig 81. A section through the dies is reproduced in Fig 82. This shows that the embossing punch A is provided with a

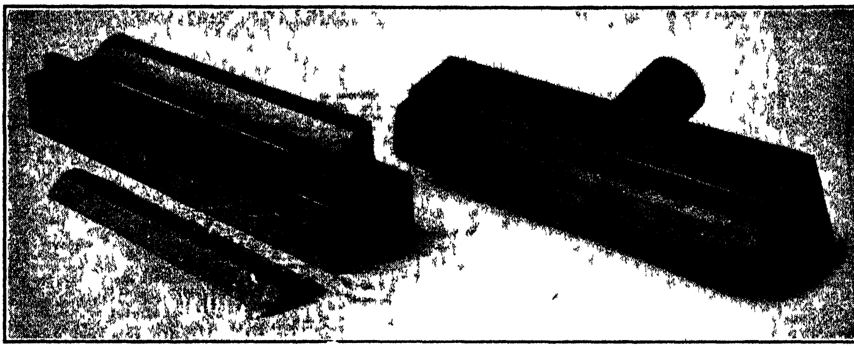


FIG 80 —The forming dies.

heavy pressure pad controlled by ten $\frac{1}{2}$-in springs for holding the work in the die seat B while the formed edge is concaved to the form at C. The opposite end of these dies is made to flatten the surface along the short

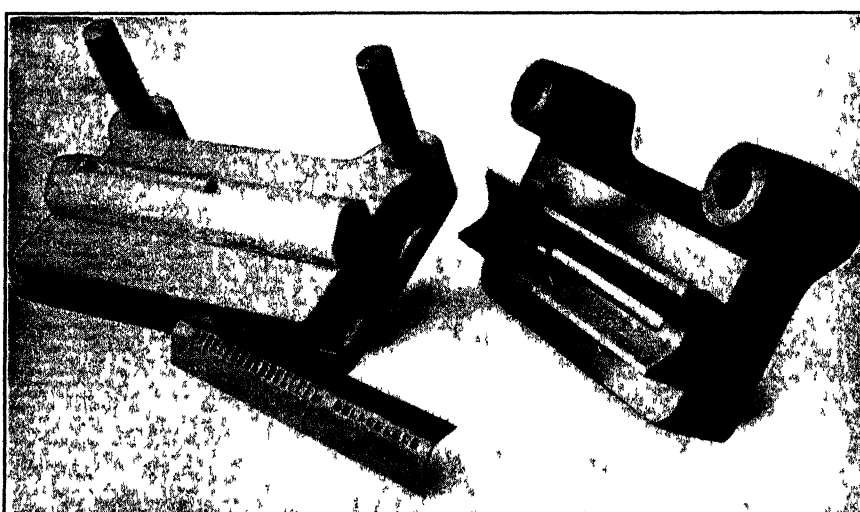


FIG 81 —The embossing die.

series of holes at the other end of the work. Afterward, the bevel edges at X (Fig. 76) are produced by a milling process.

The final operation in the press tools is the trimming of the edge to a definite distance from the sighting holes. The tools for this are shown in Fig. 83. The method of holding the work on the fixture (for the die

is in the form of a tool of this character) is with the formed cover plate resting upon a locating ledge on the face of the device while two knurled head screws are used for clamping the work in place. In this position the projecting edge of the piece will be trimmed to the exact width required. The cover before and after trimming is shown in Fig. 83.

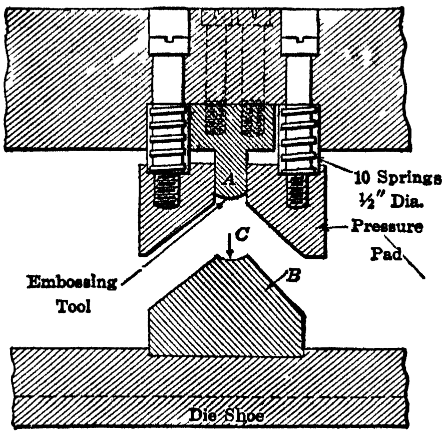


FIG 82 —Section of embossing dies.

The punch or upper trimming tool is sheared lengthwise about $\frac{1}{16}$ in. in the length of 10 in. and also has a side clearance of about 5 degrees, both being to assure free cutting action and smooth edged results.

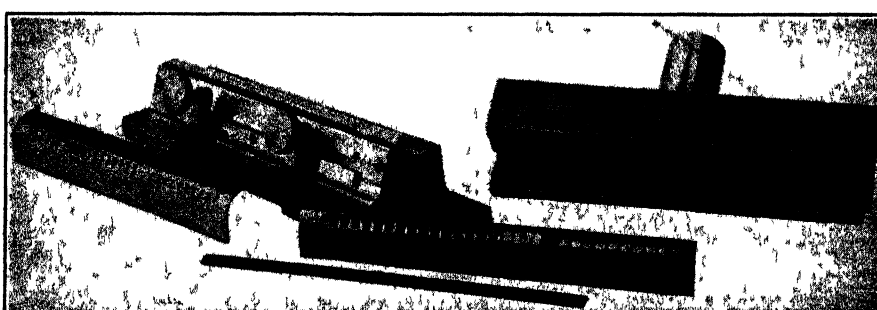


FIG 83 — The trimming tools

Drawing and Forming a Four-sided Cover

The illustrations that follow relate to the manufacture of a form of mechanism cover. The production of this article involves the application of the processes of blanking, drawing, trimming, piercing, and forming in press tools, and the taking of one cut in a milling machine. The sequence of operations is represented by the group photograph, Fig. 84, which

shows the work from the blank to the finished cover. In this view, *A* shows the blank; *B* the first draw; *C* the second draw; *D* the piece

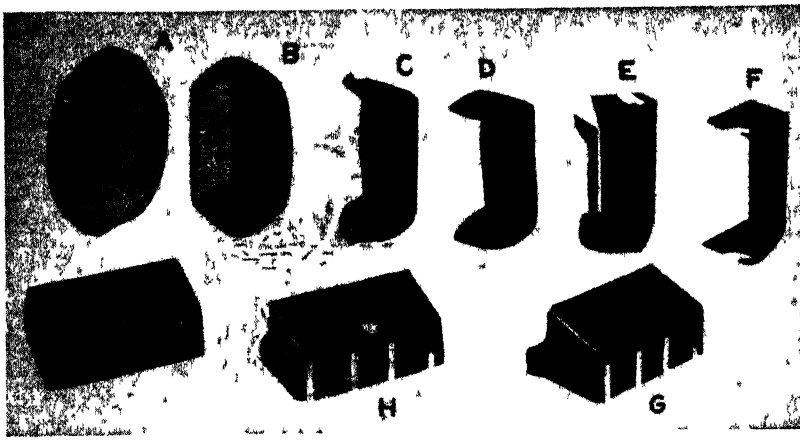


FIG 84 —Sequence of operation on a small machine cover

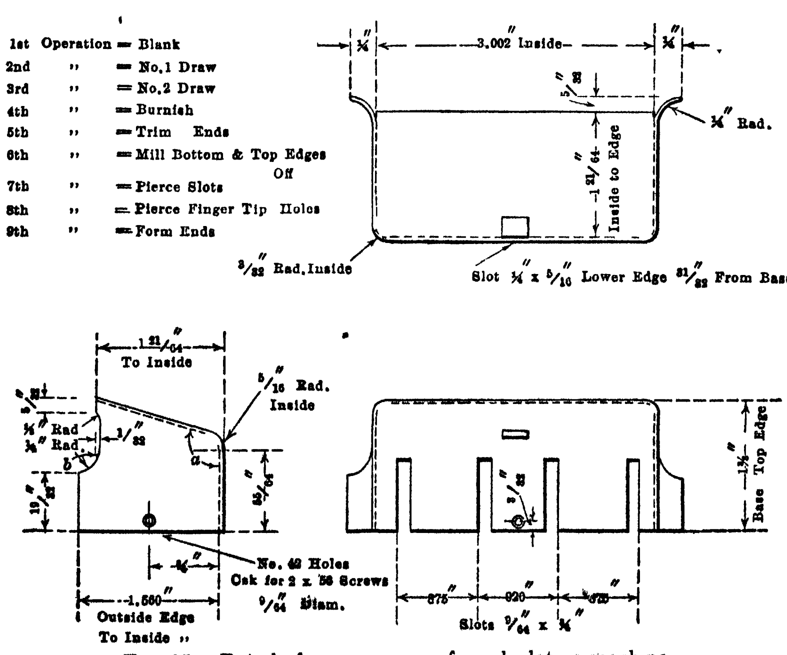


FIG. 85.—Detail of carriage cover for calculating machine.

burnished; *E* the bottom and ends milled off with a cutter; *F* the ends trimmed; *G* the finger hole and slots pierced; *H* the completed cover with ends bent to shape.

Details of the cover are given in the drawing, Fig. 85, and the operation schedule is included in this engraving. The piece is made from 0.040-in. brass stock.

The blank is made with dies of simple sectional construction, being constructed in halves. It makes a blank similar to *A*, Fig. 84, which is of elliptical form with a length of 5¾ in and a width of 3 in. The operations that follow give a good opportunity to study the evolution of a blank of this contour through the successive shapes it assumes until it is completed.

The Drawing Operations

The first drawing operation is accomplished with the dies in Fig. 86. In this case the die proper *B* is the upper member of the set and the punch

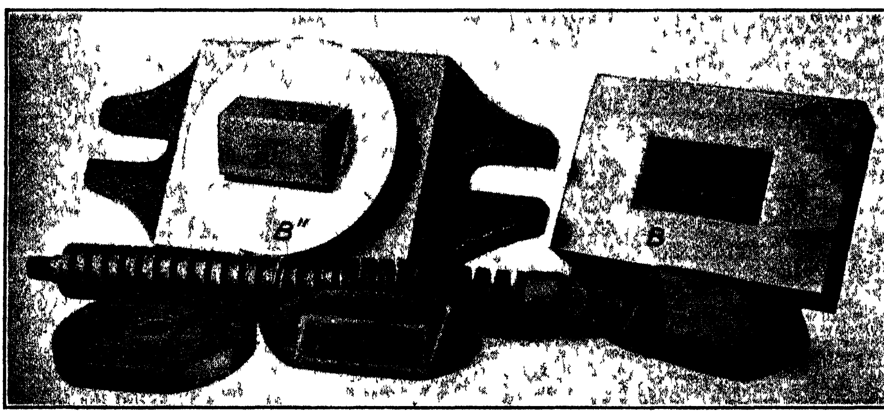


Fig. 86.—First operation drawing die.

B′ is carried by the cast iron base to which it is attached by fillister head screws and dowels, let in from the underside of the shoe. A drawing pad or pressure pad *B″* is provided which fits over the drawing post or punch *B′*, and this is acted upon by pressure pins which extend down through the base and rest upon a spring plate *C*, which receives the upward thrust of the long coiled spring which, when assembled in working position, is secured to the base by the threaded rod shown, this being passed through the center of plate *C* and screwed into a tapped hole in the base.

This first drawing operation produces a piece drawn in at an angle of about 110 degrees (to correspond with the included angle at the closed side of the cover at *a*, Fig. 85) and to a depth of about ⅞ in. The second drawing operation with the tools, Fig. 87, draws the box form to depth as shown by the work at the front of the dies. These tools are in general similar in construction to those for the first draw and they use, in fact, the same pressure plate and spring below the drawing post base. The

die, however, is provided with a spring knock-out. Both drawing operations leave the work with flared out ends which indicate the manner in which the stock is held between the drawing surfaces to prevent wrinkling of the work.

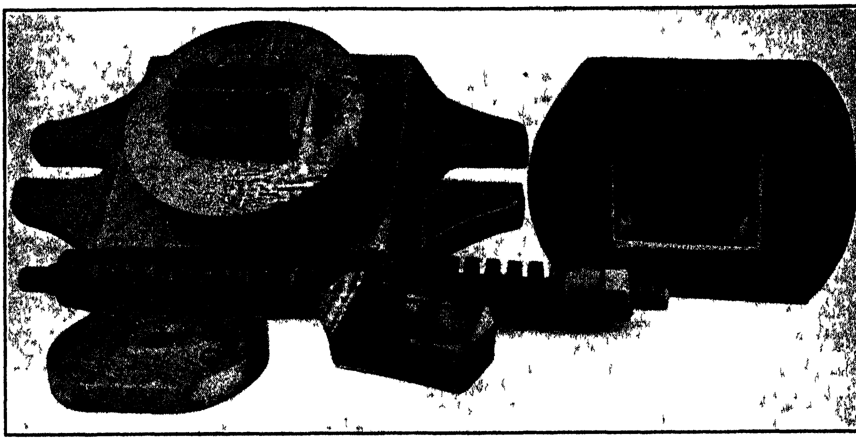


FIG. 87 —Tools for second draw.

The next operation is in the dies, Fig. 88, where a "push through" construction is used, these dies straightening out the sides of the work and having a burnishing effect upon the walls.

It should be noted that all of these drawing dies have a liberal radius for the corners to allow the metal to flow into the die without breaking,

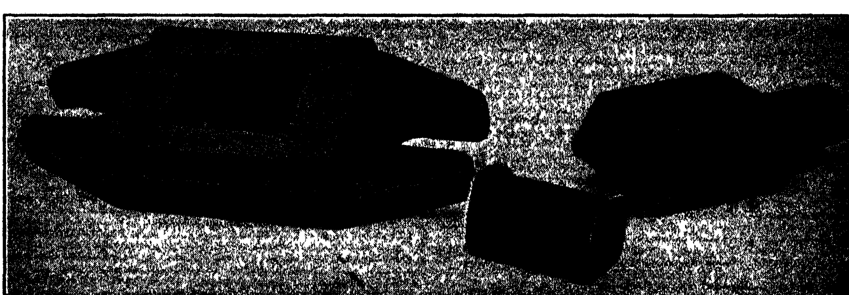


FIG. 88.—"Push through" dies for third draw.

and the spring tension is regulated to give the desired gripping pressure on the work between the opposing surfaces so that wrinkles are avoided.

THE TRIMMING OF THE ENDS

The trimming of the ends in the following operation is done with the tools in Fig. 89. These dies are of novel design. They are arranged to receive the drawn cover which is slipped vertically over the die proper and

which is then cut out at the edge by the trimming punches to form a concaved opening or notch at that point. The dies are double, right and

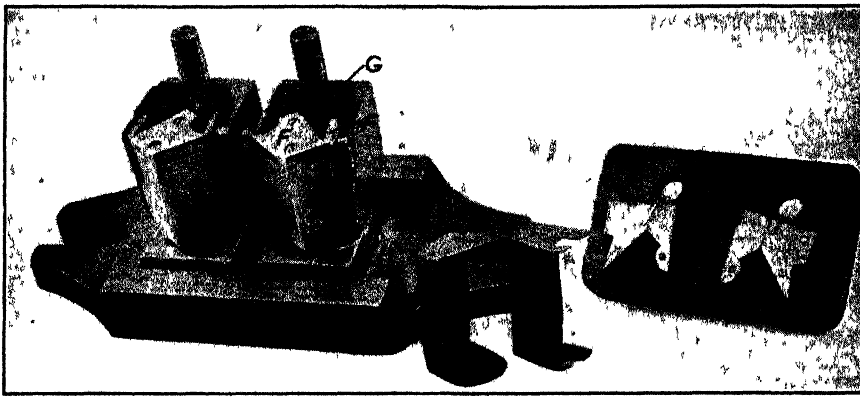


FIG 89.—Trimming dies.

left hand, and the work is first trimmed at one end over one of the dies, then placed the other end up on the other die for the trimming at the second end.

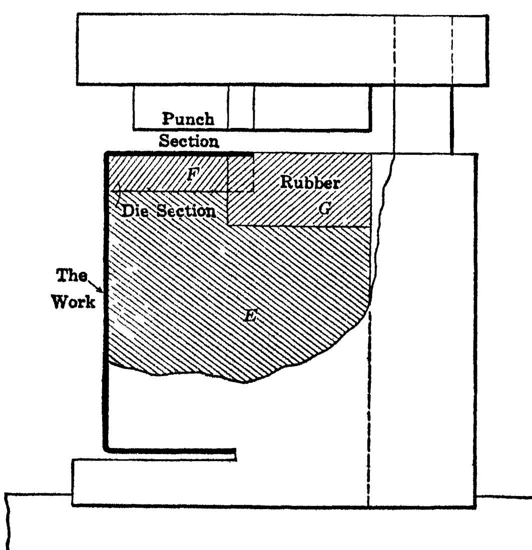


FIG. 90.—Section through trimming die.

The shape of the notch cut out by the trimming tools is indicated at *b*, Fig. 85, although the full depth is not here represented as the drawing shows the cover in completed form after a milling operation has been attended to.

The trimming dies, Fig. 89, are made up of machine steel blocks E to which are secured hardened tool steel die sections F which are seated against the main block and secured by fillister head screws and dowel pins. The blocks E are cut away at the bottom to admit the lower edges of the work which is slipped over blocks E in upright position, with the bottom ends extending into the clearance slots referred to. The die cutting edges are backed up by a rubber pad, or buffer G which strips the scrap edge after the trimming punch rises. The latter is made in sections for convenience and each section is secured to the punch holder, as plainly indicated, by screws and dowel pins.

A sketch of the general construction of the dies is given in Fig. 90 showing the method of holding the work by slipping it over the main block and resting it on the die sections at the top. The guide posts for alining the punch holder and die base are also indicated here.

Following the trimming of these dies, the surplus metal along the long edge of the cover is trimmed off in a milling fixture with a cut similar to that indicated at E, Fig. 84. Then two piercing operations are performed.

The Piercing and Forming Tools

The tools for the first piercing operation are shown to the right in Fig. 91; these pierce the four slots in the front of the cover. The slots

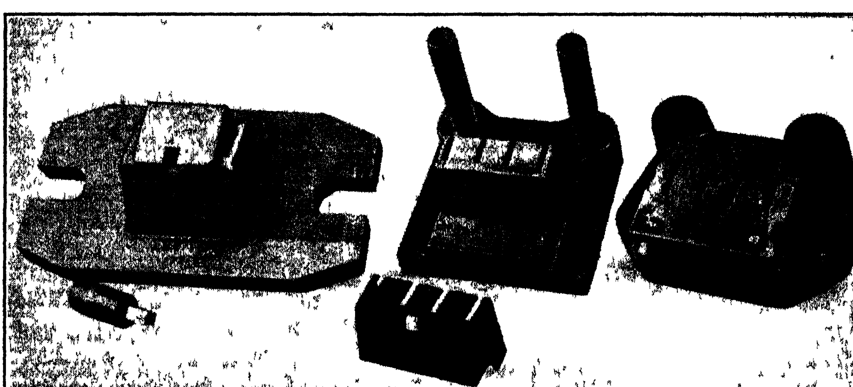


Fig. 91.—Piercing dies for finger hole.

are $\frac{9}{64}$ in. wide by $\frac{3}{4}$ in. deep and they are spaced apart a center distance given on the blueprint, Fig. 85.

The photograph of these slot piercing dies is self-explanatory. The dies are of the sub-pressed order, with stiff guide pins at the rear of die shoe and punch head. The die blocks are fitted together sectional fashion with the correct gap between sections. The punch is similarly built up with separate sections each made with a square base for securing

to the holder with screws and dowels. The punch holder carries a pressure pad and stripper the springs for which are better seen in the second view of the same tools in Fig 92.

The piercing tools for the small square hole in the top and front corner of the work are shown at the left in Fig 91. The punch is a simple tool with squared cutting portion milled on the end of a round shank and the stripper is a bent plate secured at the back of the die block and projecting forward to the corner of the die. The work slips under the open end of the stripper

The forming tools at the left in Fig. 92 bend up the curved ears at the ends of the cover to a width of $\frac{1}{4}$ in. The die block G for the forming of

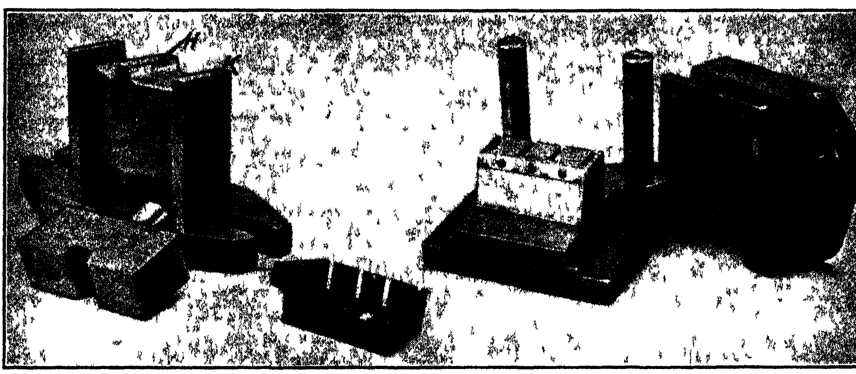


FIG. 92.

Forming die Finger hole die

these ears is shaped for the curve at H which is a projection across the face of the form block. The block G rests upon a narrow support below and its width is enough less than the distance between the uprights K of the base to provide a clearance slot to admit the edges of the cover to be formed. The projecting ears on the cover rest on the top face of ledge H. Two pieces are inserted at once, one from each side of the die block G. The punch then forms the ears down into the curved fillet at the bottom of block H.

Coin Register Dies

The dies in the following illustrations are a few of an extended line of similar tools used for making various coin register parts. There are in connection with this work many interesting problems in the bending and forming of different pieces, and one part requiring some well-designed tools for such purpose is illustrated by Fig. 93. This is a sheet steel member known as a coin changer, which is manufactured by a sequence of press operations.

The stock is 0.062 in. thick. It is cut off under the shear to approximate length and is then trimmed and pierced in the first operation dies, Fig. 94. The pierced blank then appears as in Fig. 95. The dies are so clearly shown by the half tone and line drawing as to need little in the way of description. A few features may, however, be referred to briefly.

The sheet metal plate locates against gage pins *a*, *a*, *a*, Fig. 94, and when the punch plate descends with the end-trimming and piercing tools, the pressure pad *B* holds the plate securely and acts as a stripper when the

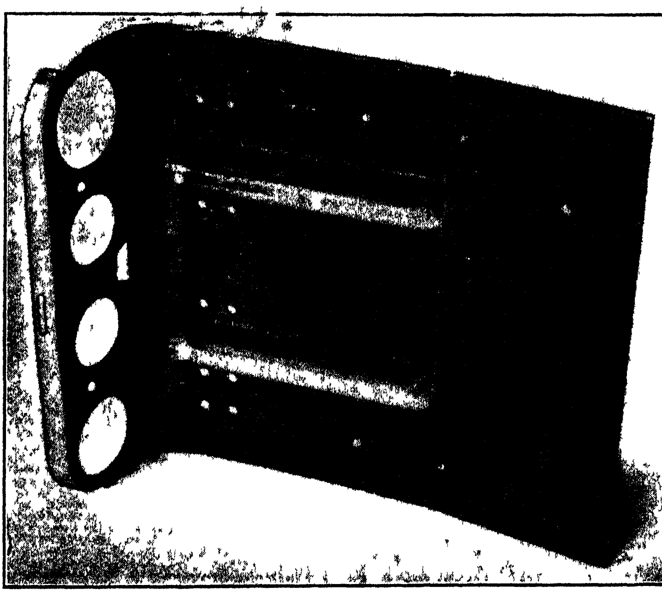


FIG. 93 —Underside of coin changer back.

punch ascends. The punch plate carries one bending punch *C′* which forms up the lip at *B*. This punch has three cutting edges to outline the tongue of metal or lip *C*, but the back face is narrower than the die opening so that the effect is to cut the outline of *C* around the three corners and then fold it down into the opening in the die as shown by the sectional sketch at the side of the drawing, Fig. 94.

The large holes pierced in this die are $1\frac{3}{8}$ in. diameter. The small holes are $\frac{3}{32}$ in. The piercing punches are set into the plate *D* and the latter is secured to the punch holder by a number of fillister head screws and dowel pins. The small piercing dies are of the bushing type and readily replaced if required. The end trimming is done by tools *E*, carried by the punch head, and *F* secured to the die shoe. These tools are really on the compound order, the punch section *F* of tool steel being bored and ground out

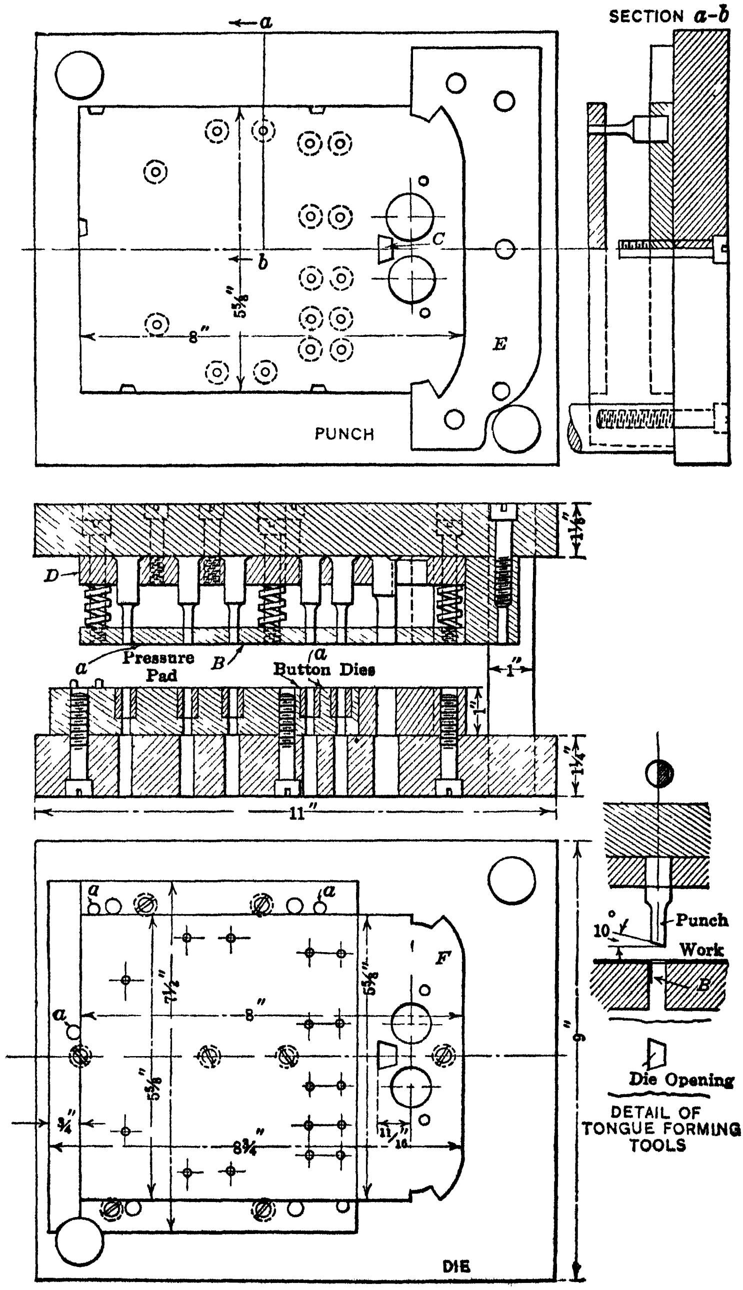


FIG. 94.—End-trimming and piercing tools for first operation.

for the die openings for the large pierced holes. Like the rest of the dies in the series, these are provided with guide pins at the corners of the shoe and holder.

The work as it comes from these dies is shown at Fig. 95. Figure 96 illustrates it as it appears after the next operation where the front end is formed and bent up to the round cornered lip indicated at *L*.

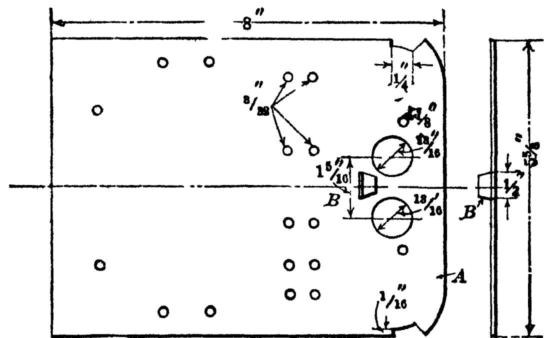
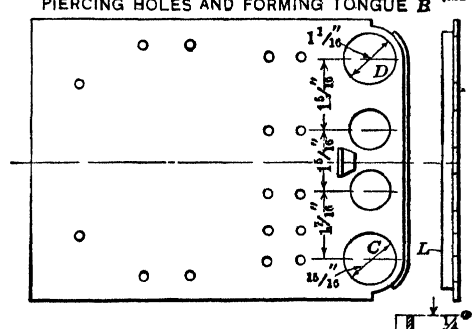


FIG 95 FIRST OPERATION TRIMMING END *A* AND PIERCING HOLES AND FORMING TONGUE *B*



SECOND OPERATION PIERCING HOLES *C-D* AND FORMING UP LIP *L* AT END

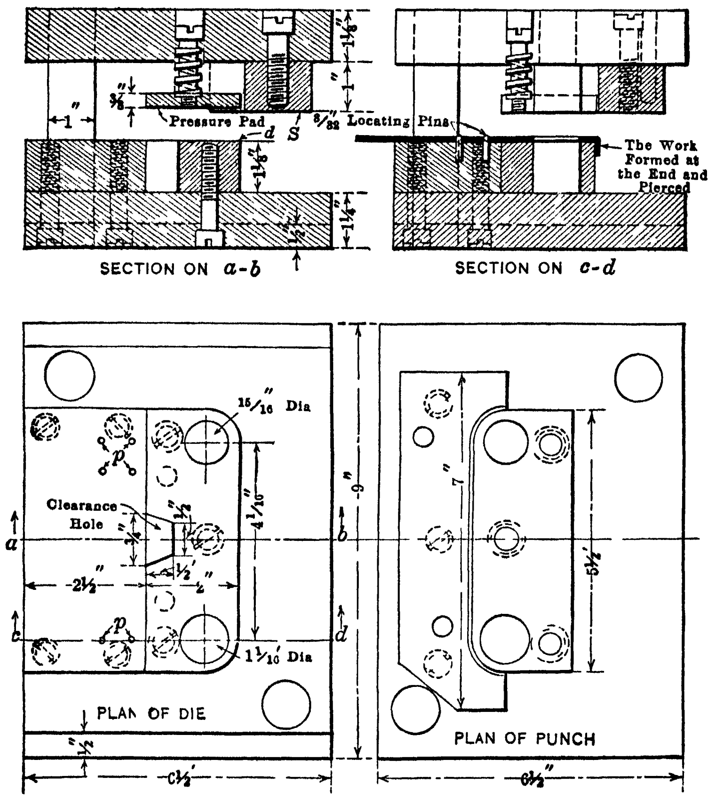
FIG 96

FIGS. 95–96.

THE END-FORMING DIES

The dies for forming this shallow flange or lip are shown by Fig. 97. Referring to the latter view it will be seen that the tools are also used for punching two large holes which are respectively $\frac{15}{16}$ and $1\frac{1}{16}$ in. in diameter. So the operation is again of the combination type. The blank rests over the series of locating pin *p* with its end to be formed projecting over the edge of the die at *d*. The punch section *S* is made to allow just the thickness of the material between its inner edge and the corresponding face *d* of the lower die and when the punch descends it folds the flange down over *d* and forms it to shape.

The clearance hole marked on the die is to admit the narrow tongue formed in the first operation and thus keep it free from the action of the second operation tools.



FORMING AND PIERCING TOOLS FOR SECOND OPERATION

FIG. 97.

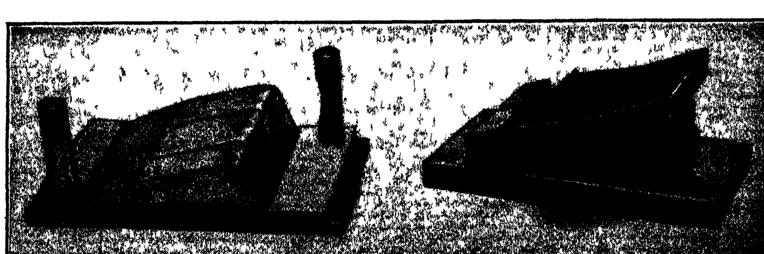


FIG. 98 —Forming tools for changer back.

The pressure pad and its springs are shown clearly, and other features of importance are all detailed in the drawing.

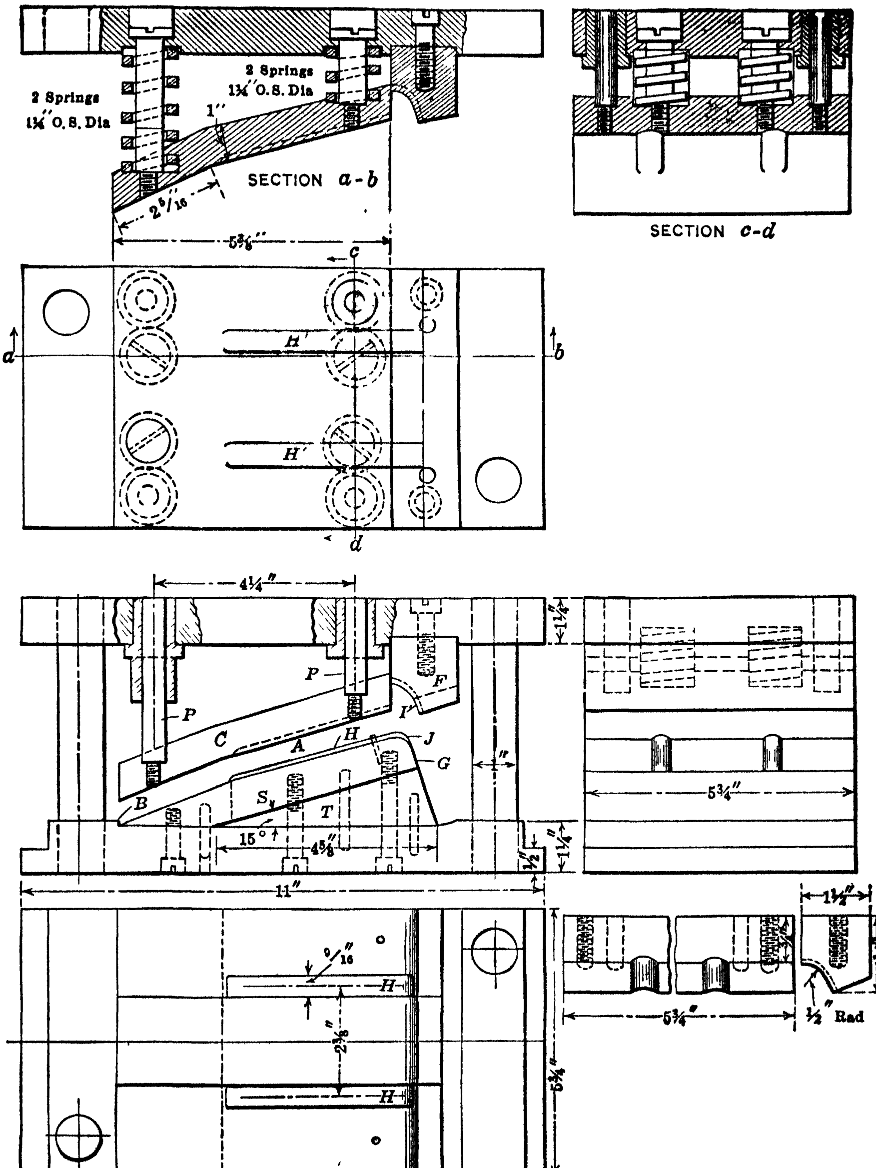


Fig. 99.—Forming dies—third operation.

The Final Forming Tools

The tools in Figs. 98 and 99 receive the lower end of the blank which rests upon the sloping face *A* of the lower die with its end against stop shoulder *B*. Upon the upper die descending the pressure pad *C* (which is supported upon four screws and four pins carried in guide bushings) holds the work and the continued descent of the punch forces the work down to the shape of the seat on lower die *A*. The pressure springs are very stiff and they carry the forming die down parallel to the face of the lower die because of the guide formed by the four corner pins *P*. At the

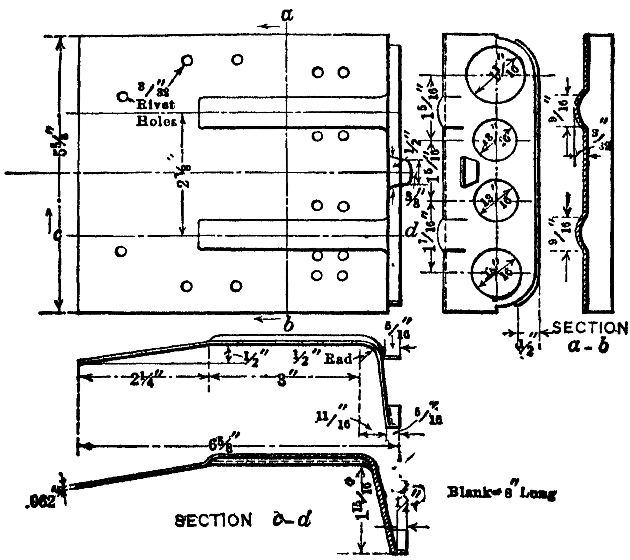


Fig. 100.—Third operation—bending and forming.

same time after the upper die has reached a certain point in its travel, the fixed form *F* bends the other end of the work down over the back of the die at *G* and forms this portion of the piece to shape.

There are two longitudinal corrugations in the work as shown by Fig. 100 and these are produced by the embossing surfaces on the dies at *H* and *H'*, respectively (Fig. 99). These grooves extend around the curved back as indicated and are continued around the corner by the corresponding surfaces of the die block at *I* and *I'* (Fig. 99).

The lower die is built up of the tool steel wedge shaped section *S* which is mounted upon a taper shoe or block *T* which gives the angle of 15 degrees.

SQUARE FORMING OF STAMPINGS

One of the common methods of forming bends or ears on stampings is to use V-dies. As pointed out by W. Kassebohm, where such dies are

not available, the pad form in Fig. 101 is satisfactory, the work being located on pins or nested and the pressure exerted against a spring or rubber pressure pad or air cushion. On the downstroke this prepressure holds the part between punch and pressure pad on the die, as in Fig. 102, thereby preventing any slipping of the work.

The bent forms produced in dies are deformations of the metal which exceed the elastic limit; but some portion of the original elasticity of the metal remains in the corners after the bending, which results in the so-called "spring back" of the form. To overcome this, various types of die are used to obtain a 90-degree, or "square," form.

Figure 103 shows at *A* a part that was formed to 90 degrees in the die but had decided spring back. The amount depends on the characteristics of the metal and on the radius *R* in the corner of the bend. If the part had been overbent, as at *B*, it would have been a square-formed job when out of the dies, since the spring back would have compensated for the overbend.

The harder the material the greater the amount of spring back. The carbon content of the steel, as well as the amount of rolling in the case of cold-rolled steel, has also a decided influence on the spring back. One-quarter hard cold-rolled steel has approximately 1 to 2 degrees spring back; one-half hard has approximately 3 to 4 degrees; hard steels have, in most instances, more than 5 degrees spring back; and annealed spring steel has as high as 15 to 20 degrees spring back.

The larger the radius the greater the amount of spring back. A small radius destroys elasticity to a greater degree and eliminates more or less spring back. The compensation allowed, owing to the character of the metal and the corner radius, is found by trial. Among other types of dies for the work, Fig. 104 shows an undercut punch which allows the part to overbend. Two degrees of undercut for the punch for forming quarter-hard cold-rolled steel is a good approximate allowance for square bends. This material is sometimes called C, or No. 3, temper with about 70 to 75 Rockwell B hardness.

Figure 105 reveals another die with punch-and-die pad ground at an angle, as at *A*, for the overbending. In Fig. 106 the punch has a slightly higher edge at the corner for punching or setting the metal at the bend and overcoming spring back. The structure of the metal, however, is affected by this corner-punching action and the method is avoided where possible.

A square U-forming method shown in Fig. 107 is much the same as that applied in Fig. 104, and another U-job in Fig. 108 duplicates the principle of Fig. 109. The double angle has of course to be found by trial. It is important that the corner over which the work is square-formed be lapped or given a highly polished surface, thus allowing the work to be formed without galling or scratching.

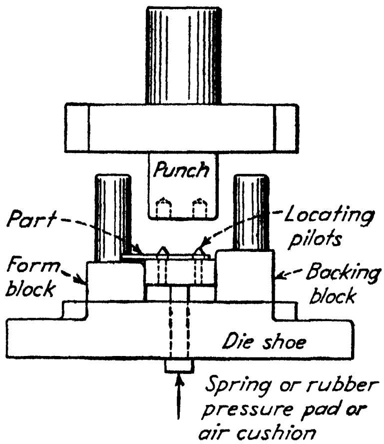


FIG. 101.

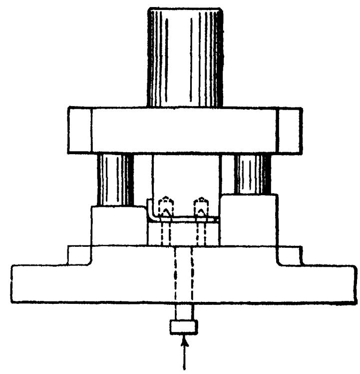


FIG. 102.

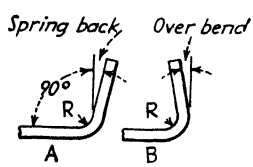


FIG. 103.

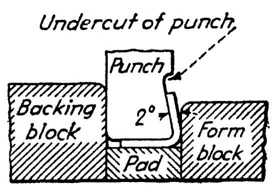


FIG. 104.

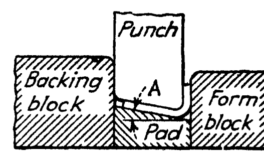


FIG. 105.

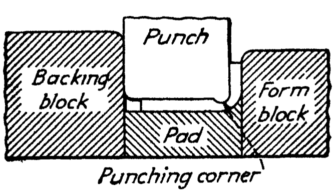


FIG. 106.

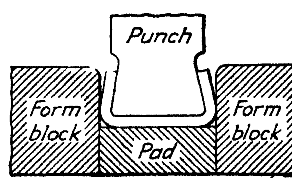


FIG. 107.

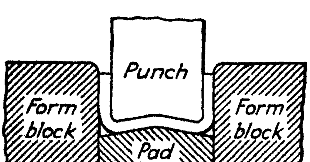


FIG. 108.

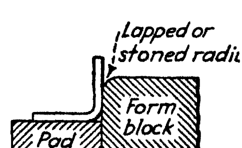


FIG. 109.

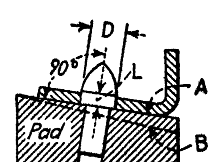


FIG. 110.

FIGS. 101–110.—Dies for square forming of metal stampings.

Parts are sometimes located on pilots on a form die or pad and if the pad has an angular surface, as in Fig. 110, the pilot should be perpendicular to the angular seat.

The best forms are obtained without breakage or cracks with one-quarter hard cold-rolled strip steel, or No. 3, which bends 150 degrees "across" the grain, at a sharp angle of 90 degrees "with" the grain without showing signs of failure One-half hard, or No. 2 temper, stock will allow a sharp bend "across" the grain, but 'with" the grain only a bend with large radius can be made without signs of failure.

CHAPTER XV

SIDE-OPERATING TOOLS

Side-operating or side-closing dies in their different designs represent means for performing—through lateral movement of the punch—such operations as piercing, folding or forming, and sometimes shallow drawing of certain portions of the blank where horizontally located tools can be forced in to do their work from the side instead of being operated vertically in the usual manner. Occasionally the side-closing tools are combined with regular dies for working simultaneously with blanking or piercing tools. They are more commonly employed, however, for second-operation purposes except perhaps in the case of very long press runs where additional detail worked into a set of tools is justified in so far as rate of operation is increased by this means.

The operation may be the punching, indenting, or piercing from the side or end of the blank, or it may be performed from the inside of the work, as where a bulged or extruded portion may be required at the outside of a shell or other object. Or, again, punches may be forced in at an angle in either plane for obliquely directed performance, or they may be pivoted members to be swung into action either outside or inside the work, by means of suitably arranged operating wedges, cams, or rocker arms actuated by the up and down movements of the press ram.

Another class of work performed with side-operated tools consists in curling the pieces, especially where the shape and size are such that the work is best handled resting flat on the die while horizontal dies are forced in laterally to produce the rolled-up or curled effect on certain portions of the piece.

Ordinarily the simplest application of the side-operating principle involves little more than the use of one or more wedges attached to the punch head for closing the dies inwardly against the action of a compression spring. This arrangement is modified at times to the form of a straight cam which is moved up and down with the action of the press and provides a positive relief motion of the tools on the up-stroke following the closing-in motion on the down movement of the ram.

In some constructions a toggle form of connection is used for sliding the side punch or die forward, this toggle unit being operated by a rod attached to an arm at the side of the press ram. Other designs may employ a pinion and rack, the latter attached to the side of the slide for reciprocating it horizontally with the up and down action of the ram.

Not infrequently the working portions of side-operating punches or dies are actuated from the center outwardly, by a cone- or wedge-shaped plunger located through the center of the regular punch holder or shank. Radially placed piercing punches or certain kinds of forming tools are readily operated by the centrally located wedge or plunger.

Dies for Long Pieces

The tools in Figs. 111 and 112 are curling dies for loose-leaf book base and back. These parts are of sheet steel and are shown in Figs. 111

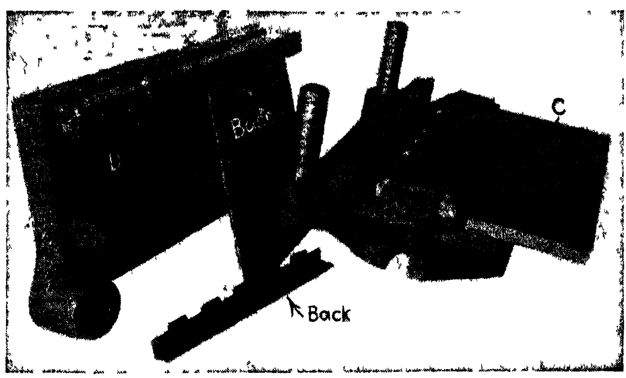


Fig. 111.—Wide curling dies.

and 113. The latter shows a dimension of 12 in. for the length of these two parts, but this size varies with different book sizes. The curling dies for forming the hinge sections of base and back are so constructed as to take care of different lengths and widths of work. The tools give a curl of $\frac{5}{16}$ in. outside diameter, practically a complete circle being formed up in the operation. The curling dies are made, as shown in Fig. 112, of a series of separate dies *A*,*A* mounted side by side. The rear ends of these die sections are beveled to an angle of about 30 degrees to correspond to the working face of the punch member *B*. The action of this member is to force all die sections *A*,*A* forward to act upon the work simultaneously.

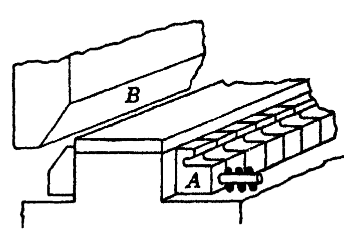


Fig. 112.—Layout of curling dies in Fig. 111.

The sectional construction permits the dies to be hardened without liability of warping and also gives opportunity for setting up for different lengths and positions of hinge sections on the book base and back if desired. In hardening and finishing a die of this character it is an easy matter to surface-grind the angle on the heel of the die for the desired slope, but the forming or curling end is not so easily taken care of in the

case of a long single-piece die if it should warp in the hardening and drawing operation. With the sectional arrangement after hardening dies they can be placed with their working ends in alinement and their beveled rear ends ground to an exact plane.

The plate C, Fig. 111, carries a stop shoulder for locating the work and backing it up against the thrust of the curling dies. The stops can be changed to suit the different sizes of book bases and backs which are to be curled in this set of dies. The pressure pad D for holding down the work is backed up by a set of springs which causes the work to be gripped

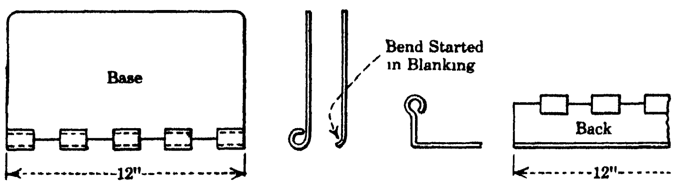


Fig. 113.—Curling performed in dies on Figs. 111–112.

positively against possibility of slipping during the curling operation. Die base and punch head are maintained in relation to each other by means of guide posts.

How the Curl Is Started

It is difficult to start a curl from a straight-edged blank, and provision is made to aid the process of rolling the stock up into a smooth, circular form. In blanking out the piece shown, a slight radius formed on the end of the blanking punch along the outside corner causes the blank to come from the first-operation dies with an edge slightly bent up as in the sketch in Fig. 113. This is to start the blank properly in the curling dies, with the result that the curl is formed up smoothly. The radius on the heel of the blanking punch will vary somewhat according to the thickness of the metal to be curled; it will be about $\frac{1}{32}$ in. on usual work. This radius on the blanking punch gives enough of an upward bend to the edge of the blank to cause it to follow around in the curling die curve.

Another Piece of Work

In Fig. 114 are dies for curling the hinge portions of a thin member shown in Fig. 115. This piece is the cover of a package unit used in a vending machine, and the same dies are used in making the corresponding curls on the box itself. The package unit will be seen lying on the bench in front of the dies in Fig. 114. The stops on the die take care of both package container and cover. The curls are about $\frac{1}{8}$ in. outside diameter. They are made by two sliding dies in the base, both operated uniformly by the two wedges at E, Fig. 114. One of the dies

is shown in the sketch, Fig. 115. The two dies are held in place in their guide grooves in the die base by a cover plate which in Fig. 114 is shown

Fig. 114.—Dies for curling a package unit

removed. This view shows the spring pressure pad for retaining the work in position for the curling operation.

The long stop plate and work support at F is required for handling the package unit itself, which before folding up into its box-like form has a length of $10\frac{1}{2}$ in. This thin blank is produced by shearing; its width is $4\frac{1}{4}$ in. After the sheared stock has been curled in the dies illustrated here the work is folded up into box form by means of forming dies which are not shown here.

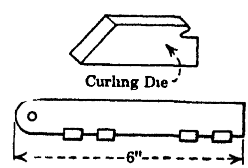


Fig. 115.—Another hinge curl.

Angular Curling

Another piece of work is represented by the sketch Fig. 116. This is a piece of light gage brass with a small, open curl formed on the corners at one end so that the two curls face each other at an angle of about 45 degrees and serve as a part of a clasping device. The piece is pierced and blanked in an earlier operation. The work before and after curling is shown in the photograph, Fig. 117.

Fig. 116.—A curled clasp.

For curling, the work rests upon a nest between locating pins and end stop. It is held securely in its seat during the curling by the

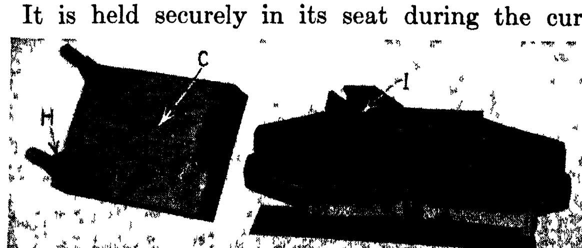


Fig. 117.—Curling dies for clasp, Fig. 116.

spring pressure pad C, Fig. 117. This is backed up by four springs at the corners and is provided with a central ledge or projection

which comes down between the locating pins on the die face and grips the work tightly.

The wedges for moving the curling dies forward against the work are placed in angular position in the punch face at H. As shown in Fig. 118, they are made with a flat body with ends finished to cylindrical form, so that the upper end is fixed in a seat bored in the punch face while the lower end is piloted in a bushed hole in the die base.

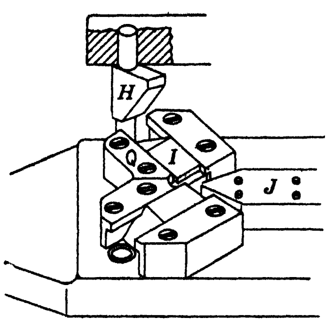


FIG. 118.—Arrangement of dies in Fig 117

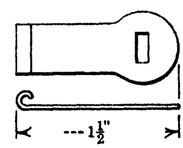


FIG. 119—A curled hook.

The position of the curling dies and the method of housing them in guides secured to the die base by fillister head screws and dowels will be

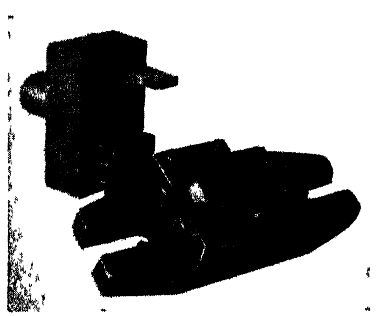


FIG. 120—Dies for curling hook (Fig 119)

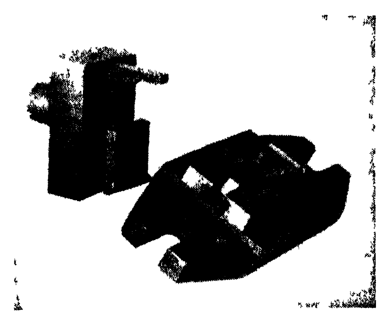


FIG 121—Dies for curling fastener shown in Fig 122

clear upon examining Fig. 243. The angular dies are here shown at I between their guides. The locating nest is indicated at J.

Another curled piece is shown in the sketch, Fig. 119. The dies for this are shown in Fig. 120. The work is thin brass and has a full curl of $\frac{1}{16}$ in. formed at the end. The piece of Fig. 122 curled in dies, Fig. 121, is finished with a $\frac{1}{8}$-in. open curl.

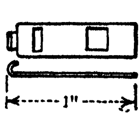


FIG. 122—A fastener curled in dies in Fig. 121.

The two sets of dies, Figs. 120 and 121, are of similar type, the difference being in the nest for the work and the shape of the pressure pads for holding the blanks in their seats. The operating wedges are formed with wide pilots which enter corresponding openings in the die shoes.

Section VI

HORN DIES, EMBOSSING AND INDEXING DIES, AND MECHANISMS

CHAPTER XVI

HORN DIES AND MISCELLANEOUS TOOLS

The horn, or mandrel die, is distinguished from the usual classes of press tools by the fact that a horn, mandrel, or other supporting member is used for carrying a previously formed piece while some further operation is performed, usually with the work held on a horizontal axis. The locating and supporting hub, or mandrel, may be quite short, as with some indexing dies for perforating cups, etc., but the principle remains the same. These dies frequently take the form of side-closing tools.

A FORMING DIE FOR OUTLET BOXES

In Chapter XII, Fig. 100 shows an outlet box drawn and pierced at the bottom ready for bending of the ears and punching for the side-outlet

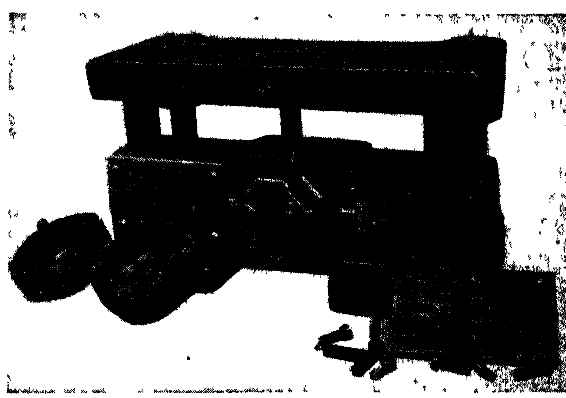


FIG 1.—Outlet box, and forming dies for ears.

openings. The same piece of work is shown in this chapter in Figs. 1 and 2 where the die is seen to be of the side-operated type. Tools of this type are commonly called horn dies. Details of the bending dies are shown in Fig. 3. First, however, refer to Fig. 4 which shows the indexing die in which the four outlet openings in the walls of the box are punched. The slugs here, as they are punched, are also retained in place and left to be knocked out when installed by the electricians. The dies are of the indexing type with four positions for the work under the punch. The work is placed on an indexing fixture at A, where two holes pierced in the box slip over driving pins B. The disk C secures the work in place and provides an outer bearing for the arbor or horn. The upper side of

the work lies on the die horn at D directly under the punch E. The indexing is accomplished by the pawl and ratchet F and G, at the rear end, these being actuated by a connecting lever and arm on the up-stroke of the press.

On the up-stroke, the work is lifted on the horn sufficiently to allow it to be indexed one-quarter way around by means of a spring pin H which serves as an ejector by acting under a plug I to clear the work from the die.

The driver plate B is operated by a floating spindle K with ball connection with the ratchet at the rear. This allows the holding fixture and work to be raised on the up-stroke of the press for successive indexing movements.

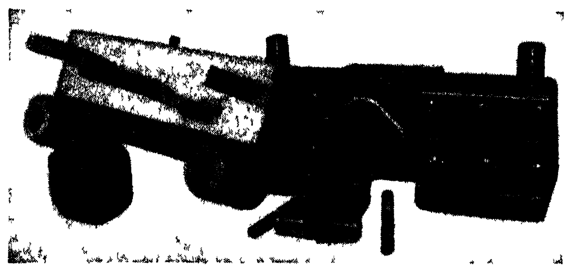


FIG. 2.—View of forming die details

FORMING THE OUTLET BOX EARS

The bending of the two small ears on the edge of the box is attended to by the dies in Figs. 1, 2, and 3. Two boxes are shown in the photographs, one with ears before bending, the other after forming. These dies are also of the horn type. The plan of operation is shown by the sketch, Fig. 3. The box is slipped over the die horn which is designed as shown in Figs. 1 and 2, with a horizontal slot across its face to allow two swinging arms which form the die proper to move laterally upon their pivots when the punch head descends. These swinging arms are shown at L, Fig. 3. The inner faces of their hooked ends form the die surfaces against which the ears on the outlet box are bent over to right angles with the sides of the box.

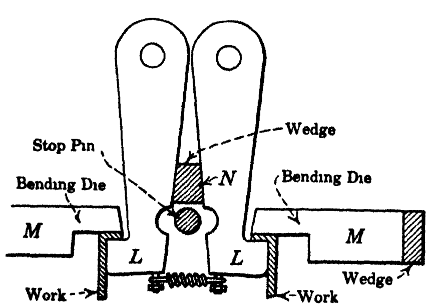


FIG. 3.—Bending dies for ears on outlet box (See Figs. 1, 2.)

On the punch head there are three operating wedges for the dies. These wedges are shown in Fig. 2. The wedge at the center operates

swinging arms *L*, *N* Fig. 3. The two outer wedges operate the side-closing punches *M*. The central wedge *N* acts first upon the arms *L*, forcing them apart so that their outer ends contact with the inside of the work. As the punch continues to descend, the wedge *N*, which is parallel

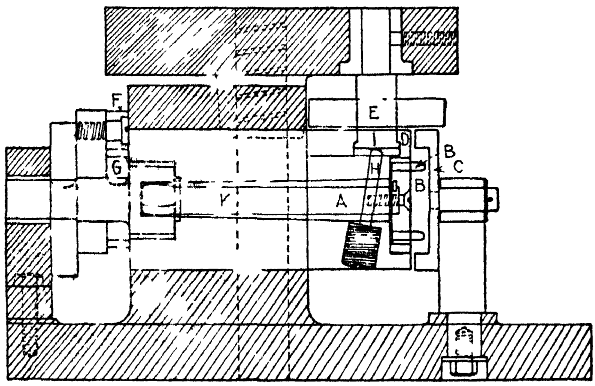


FIG. 4.—Indexing die for punching walls of outlet box.

for the greater part of its height, holds the arms *L* open at the right point, and the outer wedges *M* then fold the ears over against the inner faces of the arms which thus form the die proper for the bending operation.

The up-stroke of the press causes the outer wedges to rise, and the end-closing members *M* are drawn back by their springs out of the way,

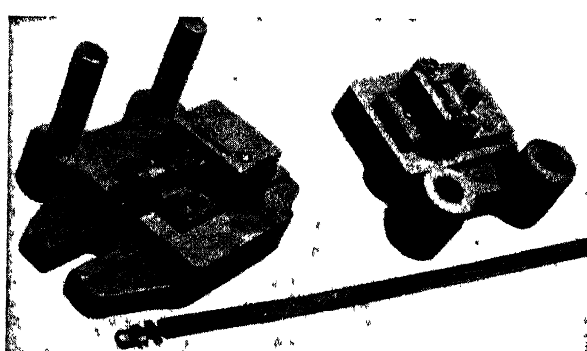


FIG. 5.—Notching and bending a piece ready for forming a square section.

and at the same time the central wedge releases the arms and allows them to be swung back to neutral position by their springs. The stop pin between them is a device for centering the jaws *L* properly so that when the work is put in or taken out the jaws are always out of the way.

The tools in Figs. 5 to 9 are first- and second-operation dies for forming up a square copper piece with $\frac{3}{16}$-in. square hole which is part of a cupboard catch, Fig. 10.

The first operation consists in passing a bar of copper $1\frac{1}{8}$ in. wide by $\frac{7}{64}$ in. thick through the dies seen in Fig. 5. Here the piece is notched at opposite sides for a length of $\frac{3}{8}$ in., and the projecting prongs are bent down to an angle of about 45 degrees, Fig. 6. Following this partial bending operation, the piece is sheared off, ready for the second operation dies. It will be seen that the first operation dies in Fig. 5 are of the progressive type. The first stroke of the press serves to notch opposite sides of the strip. The strip then advances, and the two projecting lugs are bent down slightly as shown. At the next stroke of the press the ends of the lugs are bent to about 45 degrees, as at A, Fig. 6, and the piece cut off. Following this operation, a piece is sheared off at each stroke of the press, leaving a short projecting lip as at B, Fig. 6.

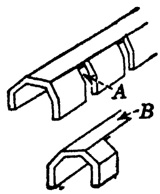


FIG. 6.—The piece is notched and partly formed in dies in Fig 5

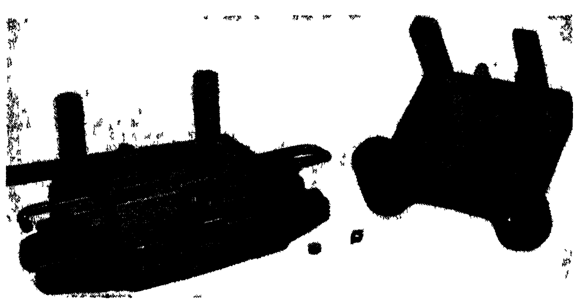


FIG. 7.—Dies for forming the work into square shape.

Now, from these dies the partly formed copper piece is placed in the dies seen in Figs. 7 and 8, where the partly bent ends are formed over

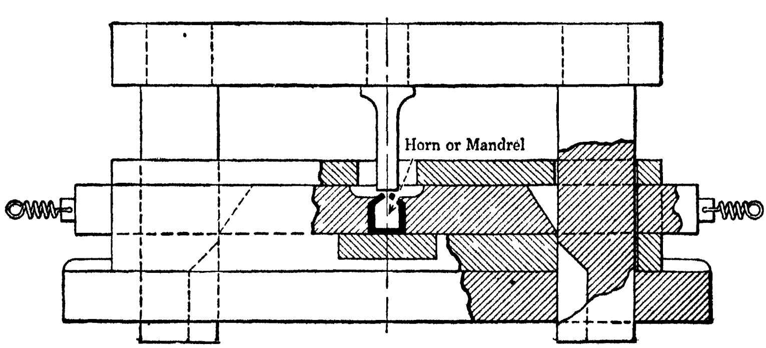


FIG. 8.—Construction of dies shown in Fig. 7.

sharply, and a short, square-shaped socket with square hole is thus produced. A square anvil or horn will be seen extending horizontally between the sides of the dies, Fig. 7, about central with the opening

in the part. Two side-closing punches are curved at the sides, and the punch head is fitted with a pair of angular-faced wedges for closing these side punches. The mandrel or horn is mounted in such a manner as to have a little floating action so that it cannot be crowded or forced to one side sufficiently to be broken. The horn is so mounted also that it may be drawn back into the body of the die. The dies are operated in an inclined press. As the ram descends, the inclined wedge surfaces of the posts on the punch head force the side-closing punches in, thus closing the work against the side of the central anvil. Continuing downward, the straight sides of the side-closing punches hold these punches tight against the work, and the top punch strikes the top of the work and closes

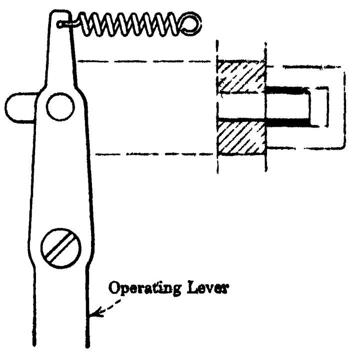


FIG. 9.—Operating lever and arbor in dies in Fig. 7.

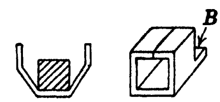


FIG. 10.—Finished work as formed in dies in Figs. 7–9.

the two ends together, thus forming a square tube or socket shown in Fig. 10. The slender ear B is left at the back end when cutting off the blank in the first operation dies. Upon the up-stroke of the press, the side-closing dies are withdrawn by spring action, and the hand lever is pulled to draw the forming anvil backward and allow the work to drop through the die shoe and out of the press.

Horn Die or Arbor for Tube Slotting

The tubing on the press in Fig. 11 is $1\frac{9}{16}$-in. seamless, bright stock, with 0.050-in. wall. The tube is cut to length of about 4 ft. and is part of the column of an adjustable floor stand for an electrical appliance. This tube is slotted on opposite sides, and the slots form a guide or keyway to engage with a locating piece on a member fitting this tube and thus preventing its turning in the outer column member.

The slot is 11 in. long by $\frac{1}{4}$ in. in width. The horn is really an arbor accurately finished to suit the inside of the tubing. It is first slotted for the die opening the same as a regular flat slotting die, then hardened and ground to the diameter of the interior of the tubing. It is several inches longer than the slot itself, and one end is fitted in a holding block at the right hand of the die shoe. This construction is shown in the photograph. The horn or arbor extends to the left parallel to the bottom

of the die shoe and with just enough clearance under it to allow the tube to be slipped in position and rest on the surface of the shoe. This supports the work solidly against the stroke of the punch and relieves the horn die of downward pressure.

The punch head carries a pressure pad which is placed like a close-fitting stripper and is machined out to nearly half a circle to fit the curved surface of the tube. It is also provided with a guide which enters between the jaws of the die shoe and definitely prevents any movement of the work and arbor and so assures positive alinement of the punch-and-die opening. Upon the upstroke of the press, the spring pad or stripper holds the work against any tendency to lift with the punch and cause the latter to be injured.

FIG. 11.—An arbor die for slotting a tube.

The slotting of the opposite side of the tube to bring the slots into exact alinement with each other is accomplished by locating the tube by an under stop or index pin which positions the work directly from the slot already punched.

As successive tubes are slotted, the "slugs" punched out are forced down into the die opening in the arbor or horn and are cleared every few strokes of the press by pushing down through the die base which is opened under the horn die.

The horn type of die is common enough as employed for varied lines of press work where certain forming or seam closing and flattening operations are required. It is not so commonly seen, however, for slotting operations, especially where long cuts of this character are to be produced.

A Heading Job

The die in Fig. 12 does the heading and swaging, or reducing, of a tube which when completed resembles a brass cartridge case of about 0.28 caliber. Actually, the job is a part of a push knob, and, after heading and swaging, the reduced end is tapped to receive a small screw, and the head is slotted crosswise in special fixtures.

The dies for heading and swaging are made with sliding block at the left side for operation by the wedge member in the punch head and with an ejector in the swaging die at the right hand which is operated by the wedge carried at the right-hand side of the punch head. The work

is placed on the holder at A, and as the dies come down the pressure pad B holds it in place. Wedge C then forces heading block D forward, and at this moment the wedge E backs up the ejector punch F so that the head is formed up, and then as the dies close further the wedge E clears

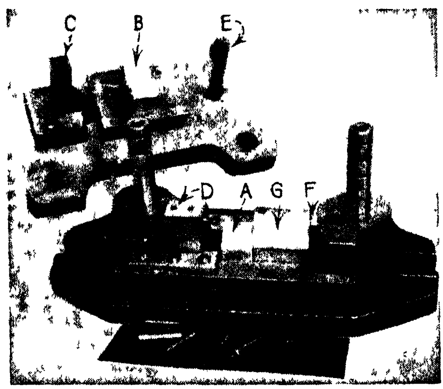


FIG 12.—Heading and reducing die

the end F, and the latter recedes and allows the shell to be forced into the die at G where it is reduced or swaged to the desired bottleneck form.

On the up-stroke of the press heading die S is drawn back by the two coiled springs at the rear, and the wedge E coming again into contact with the ejector punch F forces the work out of the swaging die.

Press-tool Attachments and Devices

Under this general chapter head which refers to Miscellaneous Tools, a whole book might be devoted to the ingenious attachments that have been devised and applied by various designers and toolmakers to different classes of press tools. This applies to modern pressroom equipment as well as to dies made in an earlier day when tools were necessarily somewhat more simple in general construction but nevertheless arranged often for high production just through the skill of the men responsible for their layout and use.

The feeding devices and multiple-tool arrangements as well as other factors in press operation have had a marked effect on production. Very often getting work in and out of the machine is the determining element in rate of output.

Naturally, as the manufacture of small-arms ammunition was one of the earliest of our mechanized industries the handling of cartridge cases through various punch press operations was developed to a point where rapid feeding of material to the dies was an important feature. The dial feed, so called, has been applied to many later lines of work.

A POSITIVE STRIPPER FOR SHELLS

A "knockoff" mechanism, like that in Fig. 13, consisting essentially of a knockout rod fitted into the center of the draw punch and actuated

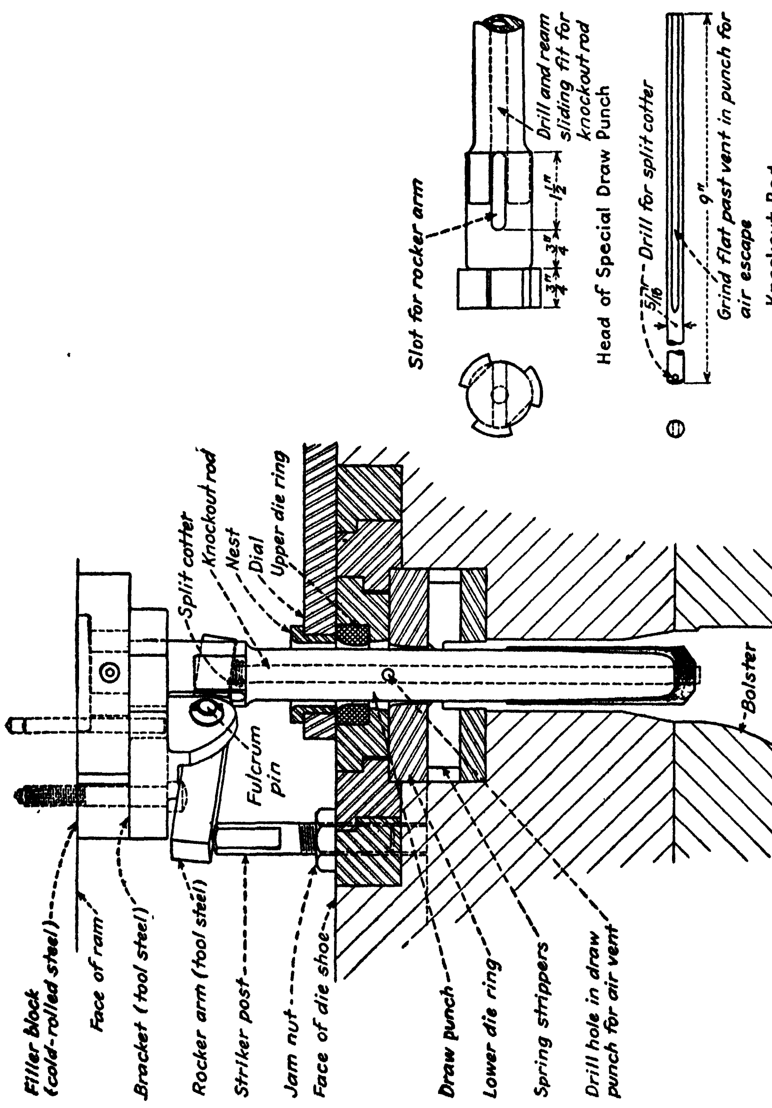


FIG. 13.—Positive stripper for shells.

by a rocker arm striking a post on the die shoe as the press ram reaches the bottom of its stroke, has been found useful, states Robert I. Miner, chief engineer, Ryerson & Haynes, Inc., in loosening drawn shells so that

they can be stripped effectively by conventional devices. It has particular value where the walls have been drawn so thin as to make conventional stripping difficult, if not impossible.

When thin-wall shells, such as cartridge cases, are ironed past one or more draw rings in the die assembly, there is a natural tendency for the inner walls of the shell to fit closely into the minute crevices resulting from machining and polishing the punch, and for the shell to "hug" that member. Conventional stripping methods of finishing a sharp edge at the lower edge of the lower draw ring, as shown at *A* in Fig. 14, or of incorporating spring strippers in the die assembly may, by careful fitting and polishing, be sufficient to strip shells satisfactorily if wall thicknesses have been held so uniform in previous draws that the upper

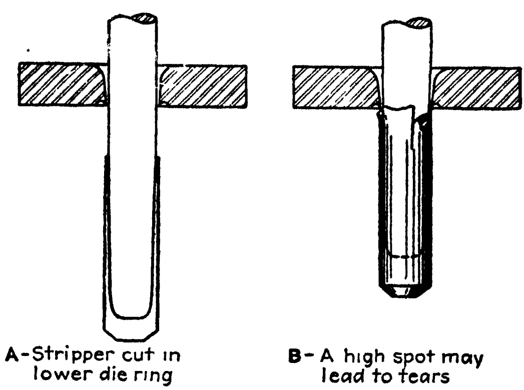


FIG. 14.

edges are fairly uniform in height. However, if a single high spot is engaged by such a stripping device, and must bear the whole load at the start of the stripping cycle, torn or bellmouthed edges, as shown at *B*, usually result.

The merit of the knockoff device shown in Fig. 14 lies in its actuation against the relatively stronger base of the shells, thus freeing them from the punch so that they may be stripped with minimum effort by one of the conventional methods. This device is in successful use in the production of 20-mm. brass cartridge cases. It is necessary only to secure movement of the knockout rod through the punch sufficient to "break" the clinging case from the punch. Usually a movement of $\frac{1}{4}$ to $\frac{1}{2}$ in. is sufficient.

Punches and dies should be given a "draw polish," in which the direction of polishing is in line with the punch axis. But even the finest of such polishing does not exclude the probability that the stripping effort will be borne by the section of the case where it is least possible to resist the effort of stripping without undue distortion.

CHAPTER XVII

DIES FOR EMBOSSING, RIVETING, AND SWAGING

Various methods and types of presses are used for embossing, coining, swaging, and the like, but the work in any case is heavy and requires substantial equipment where any appreciable amount of metal is required to flow under the action of the striking or squeezing dies. One form of press known as the Percussion type is shown in Fig. 15 in operation on steel wedges. The swaging blow is imparted by a screw-operated ram which is driven by a flywheel and which produces a cumulative blow, all of the energy of the flywheel being utilized as it comes to a dead stop. The method of drive is shown more clearly in the operating view, Fig. 31, Chapter I.

Different classes of embossing, marking, and riveting as well as swaging work are illustrated in the following pages in this chapter. These jobs are handled on various types of presses.

Typewriter-ratchet Embossing Tools

For example, in Fig. 16 are a number of ratchets like those used on certain kinds of typewriters. These toothed elements as seen here are about $1\frac{1}{2}$ in. outside diameter by $\frac{3}{8}$ in. thick, with a long hub and a $\frac{1}{4}$-in. hole bored through. The hub fits over the spindle of the rubber platen. The blanks for these ratchets are made in the automatic screw machine. The form in which they come from the machine is seen at *A* and *B*, Fig. 16, where two ratchets are shown from opposite sides. These blanks are coated with copper. A second machining operation consists in forming the serrations around the edge with the press tools shown at *A* and *B* at the left of the group of tools in Fig. 16. Then the serrations are shaved with the tools at *C* and *D* at the right. These tools consist of a shallow shaving die and of a punch that is adapted to act also as a nest for the blank. The pilot on this punch has a slot cut crosswise of the body with a spring projecting at either side and serving to retain the work in place when it is slipped over the pilot. There is at one side of the punch a locating stop *E*, which enters one of the notches in the edge of the blank and thus serves as a locating stop to position the blank in alinement with the grooves in the punch shown at *C*.

The next operation consists in placing the blank in the hand screw machine, cutting the shallow groove around the outer face, as at *F*, to

allow carbonization of the blank along this channel only. The copper surface protects the remainder of the work in the heating process.

The next operation is performed in the press with the punch and die at G and H. The lower die has at I a round-ended locating stop on which the blank is nested in position on this die and which locates the outer serrations correctly in relation to the die teeth below. This lower die also carries an ejector pin at the center for forcing the blank out of the die ring upon the up-stroke of the press. The action of the upper die in its descent over the corner pillars is to force the ratchet-shaped teeth through the side of the groove in the blank at one stroke. The next operation is hardening the smooth surfaces, the outside serrations around the blank, the ratchet teeth outside and inside wherever the bare metal is exposed by machining after copper-plating the piece. That is, wherever the blank is exposed by machining after coppering the piece, it hardens to prevent wear of the tooth edges.

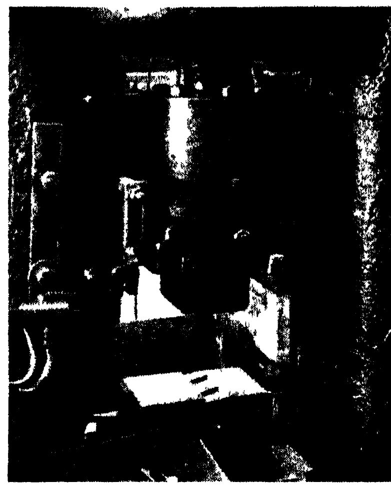


FIG. 15.—Percussion press.

A crank is used for adjusting the typewriter carriage in relation to the type, to allow for one or more thicknesses of paper, according to the character of the work being done on the typewriter. In the movement of this crank, it passes over the face of an indicator dial at the front of the machine. This dial is graduated in the manner indicated in the sketch at the right in Fig. 17, the numbers running from 0 to 16. There is a $\frac{3}{8}$-in. hole in the center of this plate, which passes over the neck of the adjusting screw. This plate is pierced and blanked with the tools shown in Figs. 17 and 18.

As will be seen upon examination of the illustrations, these press tools are of progressive character; that is, the three holes are pierced in the stock before the blanking is done. At the same stroke that puts the three holes in, the graduations and the numerals are struck into the face of the stock. The next advance of the strip of metal feeds the work against stop pins at the left-hand side of the die. The following down-stroke of the press and blanking tools cuts the work out to the outline shown. The lower face of the blanking punch will be seen provided with a conical-pointed pilot pin that enters the $\frac{3}{8}$-in. hole already pierced in the work.

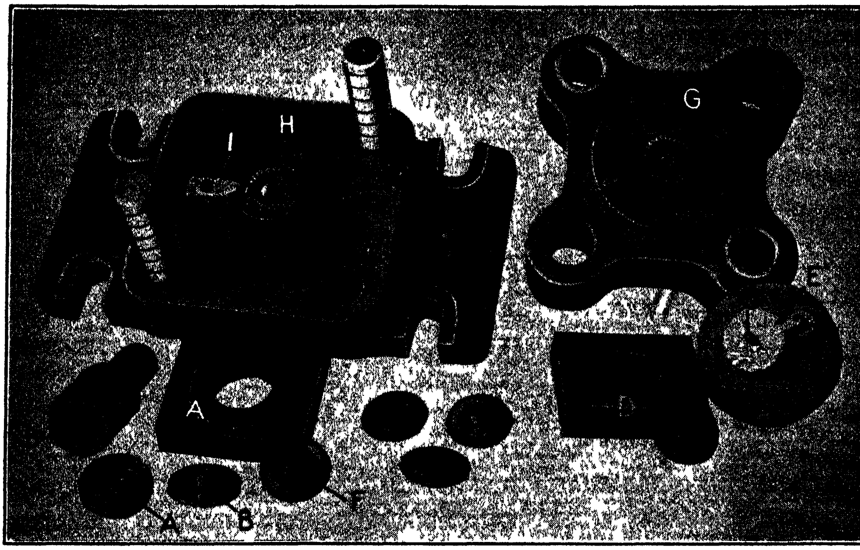


FIG 16 —Press tools for typewriter platen ratchets

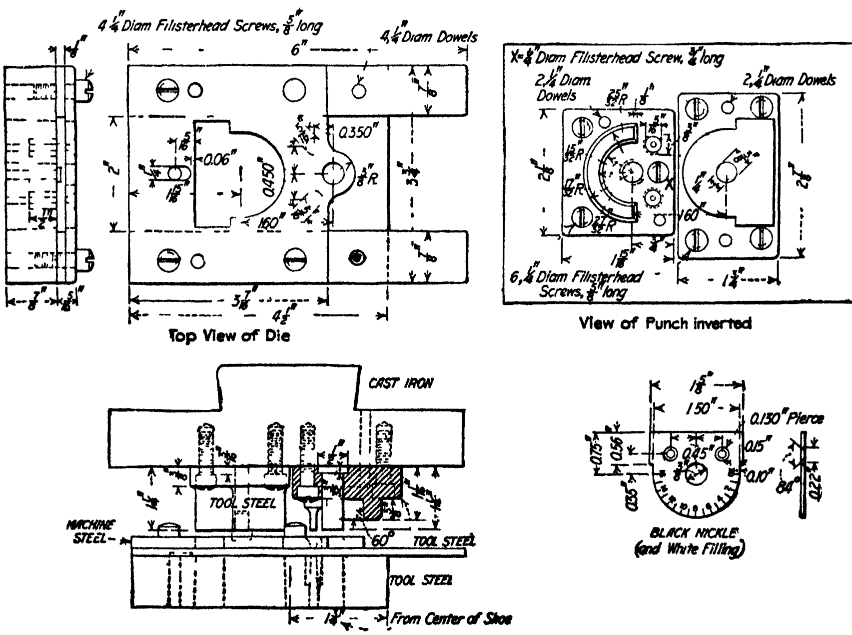


FIG. 17.—Tools for indicator.

The small piercing punches for the two screw holes are made of $\frac{5}{16}$-in. drill rod turned down to the required size for the screws. The stripper plate is countersunk deeply around the opening for these small punches in order that the neck of the punches may pass well down into the plate and give suitable support to the ends of the small punches themselves. Owing to this liberal opening in the stripper, the punches are made with a sweep-

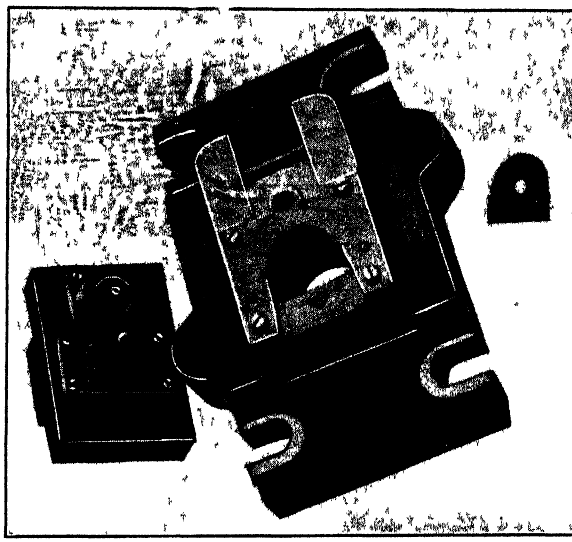


FIG 18 —Tools for indicator blank.

ing fillet instead of being brought to anything like a sharp corner. Thus they are much more substantial in operation than is often the case where a liberal fillet of this kind is not permissible.

The plan view at the upper right-hand corner in Fig. 17, showing the base of the embossing and piercing punch as well as the blanking punch, illustrates clearly the method of attaching both punch blocks to their cast-iron carrying block. Three screws are used in the case of the graduating die, along with a pair of dowels, while four screws are applied to the holding of the blanking punch itself.

An Embossed Crescent

The arc shaped piece in Fig. 19 is manufactured of 0.101-in. brass with the press tools in Fig. 20. The blanking dies at the left have no special features beyond the pillar arrangement for guiding the punch plate and the trigger form of stop actuated by the adjustable screw in the punch holder. The embossing dies are shown at the center of the group in the photograph.

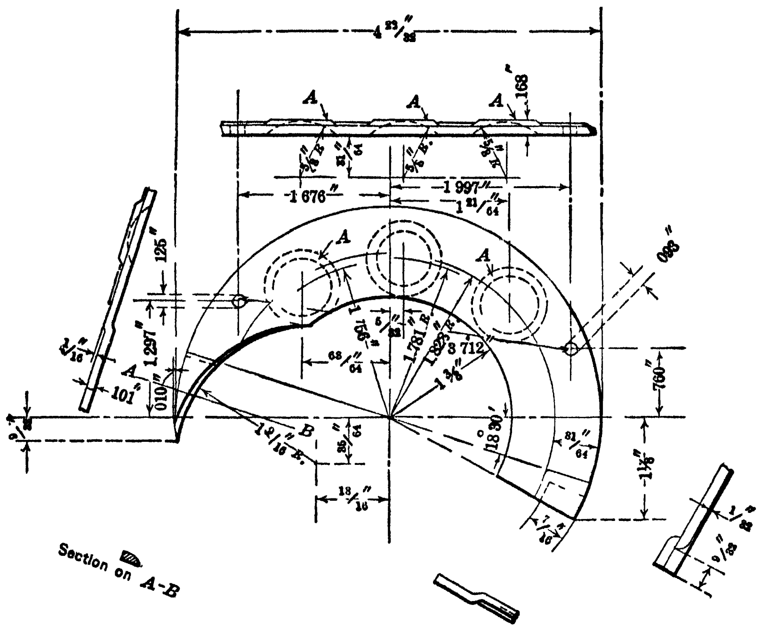


FIG 19 —An embossed piece

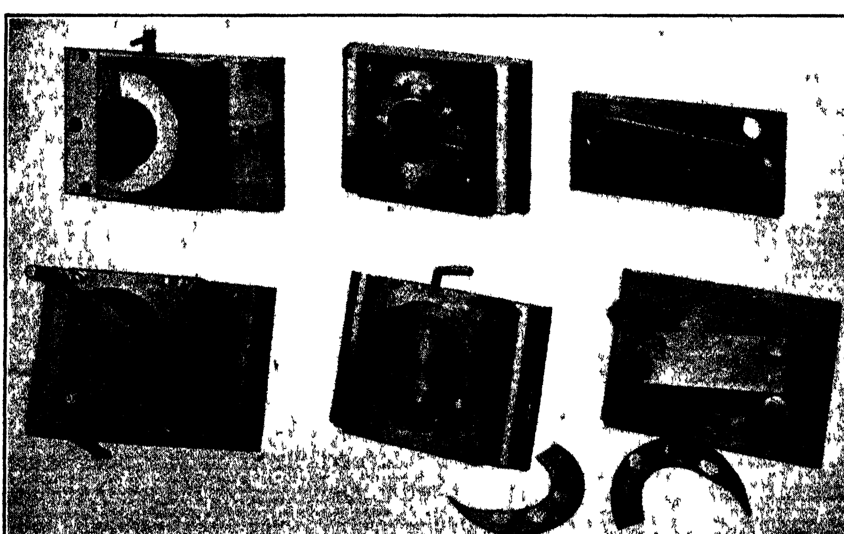


FIG 20 —Blanking, piercing, and embossing series for a coin register part.

The embossing on this piece of work consists in the striking up of the three beveled edged bosses AAA in the body of the crescent and the offsetting of the two ends from that body by an amount indicated by the dimensioned drawing, Fig. 19.

The construction of punch and dies is simple enough to require little description, as the principal features are well shown by the photograph, Fig. 20. The bottom of the die seat, which is bored out in a piece of tool steel, is lined with steel ring sections to form the die thickness at the points where the offsets are desired, and corresponding sections made the reverse of the die members are fitted into the punch proper as shown. The round bosses forced up from the surface of the metal are formed by bevel head studs of hardened tool steel seated into the face of the punch plate and operated against similar depressions bored and countersunk in the chamber of the die. The die base is provided with a knock-out in the form of small pins operated by the handle at the front which enables the work to be ejected with convenience after it is struck up.

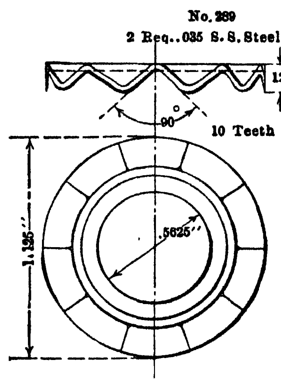


FIG. 21.—Embossed disk.

The dies at the right in the photograph receive the embossed blank and pierce two small holes through near the ends as indicated in the blueprint.

Tools for a Ring

The ring in Fig. 21 is embossed or formed with a series of radial V depressions and rises, the work being struck up between the dies in Fig. 22 at the left-hand side. The other dies at the right accomplish the previous operations of piercing and blanking the ring progressive-die fashion. The center hole being pierced at this time provides a method of locating the work in the embossing dies by slipping it over the pilot in the lower die center. The upper and lower dies are alike except for the one having a pilot and the other a bore corresponding in diameter. The two dies are turned and milled and finished and hardened and then secured to the die base and upper holder, by means of fillister head screws and dowels in the flange around the die.

Embossing an Aluminum Plate

The engraving, Fig. 23, illustrates a set of simple dies for embossing radial ribs along the bottom of an aluminum disk like the one seen to the left in the photograph. The feature of interest here is in relation to the manner of making up these tools. In the case of the die proper with concave channels running toward the center, the method of machining was to

use a formed end mill and index the die on the dividing head of the miller. The punch plate or upper die was built up with convex faced sections of

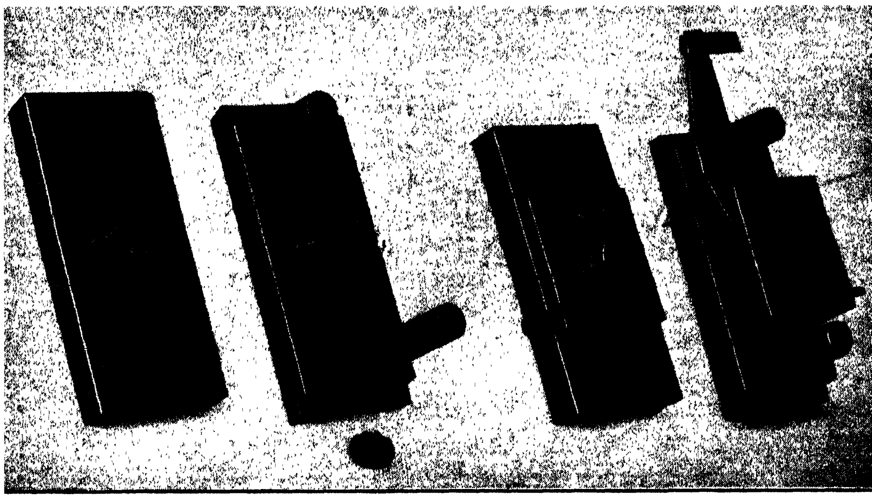


FIG. 22.—Ring embossing tools.

the right thickness and radius which were fitted into radial channels and secured there as integral parts of the die.

A Large Set of Dies

The dies in Fig. 24 are one of a number of similar sets used for ornamenting and strengthening the edges of certain sheet metal recepta-

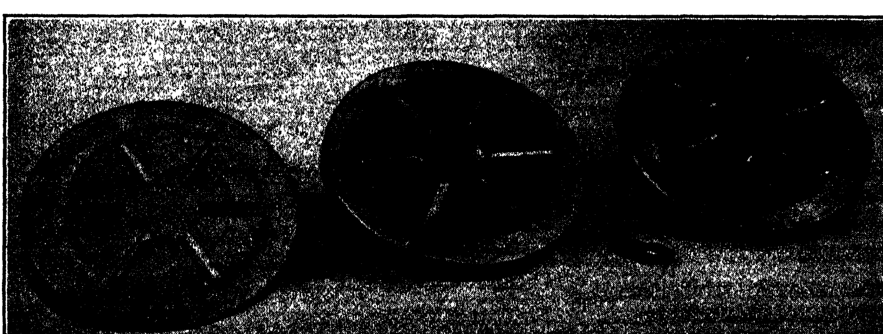


FIG. 23.—Embossing dies for a disk.

cles by embossing a simple design around the surface of the rings. The dies for this work are cast to form and finished up by filing, scraping, etc., to bring the embossing portions to sufficiently close relationship to one another to answer the purpose for which they are designed. The die

metal is a close grained iron which when poured gives a smooth surface without serious pitting or roughness of any kind.

A Stamping or Marking Die

In Fig 25 is an illustration of a set of dies for stamping the numerals on the face of the front cover of a machine to give the positions for the

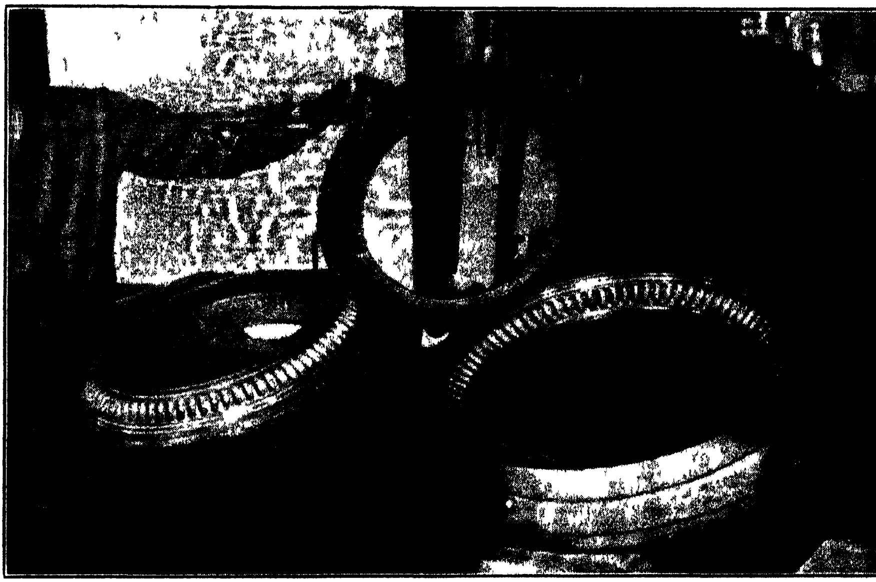


Fig 24 —Large embossing dies

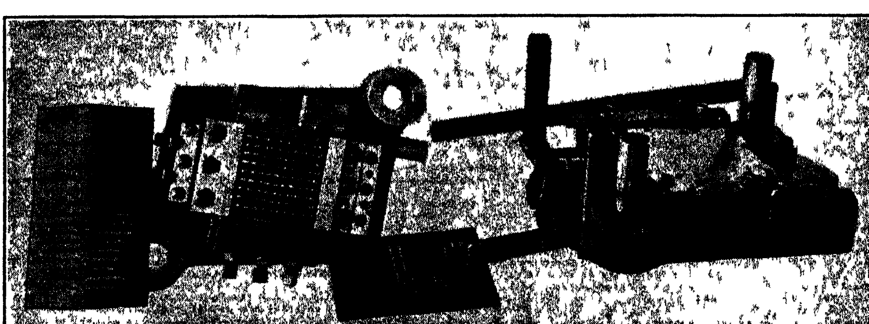


Fig 25 —Dies for stamping numerals

setting dials Fig 26 shows the work to be a brass plate 0.040 in. thick, which is blanked out a little more than 5 in. square and then stamped under the tools described. In the blanking operation the nine slots are punched out 3 in. long by $\frac{1}{16}$ in. wide, leaving a width of stock about $\frac{5}{16}$ in. for the stamped numbers.

The punch is made up of nine rows of figures from 0 to 9, the characters in each row being engraved on a solid block so that there are nine of these stamp blocks with 10 characters each. The body of the block in which they are fitted is planed out to receive them as a snugly assembled unit, and their ends are locked by clamps, setscrews acting against the ends and the sides being placed in the block to set the whole group of stamps up tightly.

The rear ends of the stamps, or figures, rest upon a hardened and ground steel plate in the punch block, which resists the pressure of the 90 characters when they are forced into the work. Similarly the base of the die is of steel hardened and ground to back up and support the work when struck with the punch.

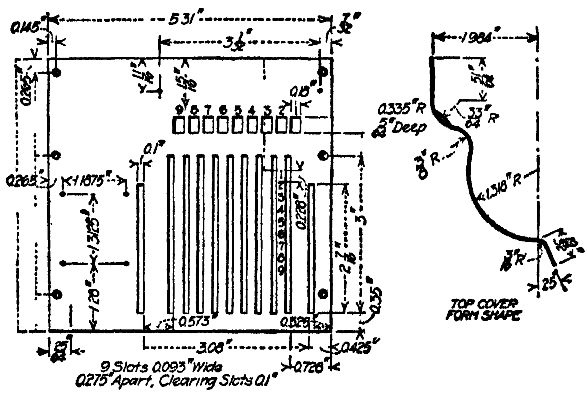


FIG. 26.—The stamped and formed plate.

It has been estimated that if this combined punch with its 90-figure stamps were to be operated under the usual power press or in a manner similar to the handling of a coining job, a pressure somewhere between 150 and 175 tons would be necessary to stamp the entire set of characters properly into the plate. These tools are, however, not used in such a press, but under a drop hammer which is a homemade machine, giving satisfactory results with little outlay for equipment.

If the illustration of the dies, Fig. 25, is examined carefully, a guide plate for the work will be noticed at the left side and at the right two small clamps will be seen. There is an adjustable stop at the rear of the die base, and at the front is located another stop which confines the work edgewise so that it is properly nested and held all the way around.

While there are two clamp screws to turn up at each setting of a fresh piece of work on the die, this takes but a moment, and the entire operation of opening the die, setting the work, and operating the drop is performed easily and rapidly.

After the covers have been numbered along their slots they are required to be bent up to the general form indicated in the end view in Fig. 26, where the central portion with the slots and numbered sections is formed to an arc of about a quarter circle, and one flat portion at an angle with the opposite edge.

The brass plate, after it has been stamped and slotted, is annealed and thus made ready for the forming process. This is carried on with a pair of simple dies made to the outline required and differing from each other only in that one is male and the other female, and the radii of the two are varied to allow for the thickness of the metal plate.

Preparing Type Bars for Riveting

This form of type bar is made of flat steel stock in the punch press with the aid of the dies in Fig. 27. The work consists in blanking the

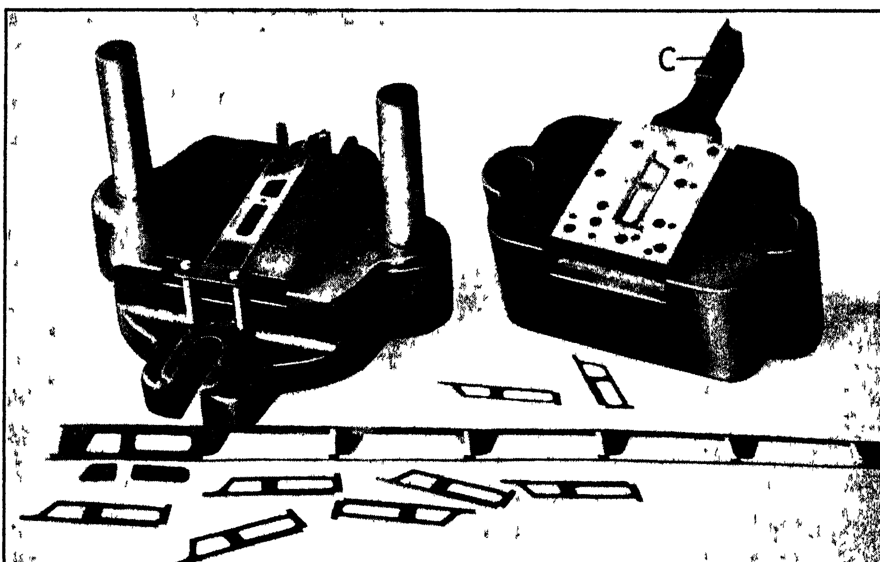


Fig. 27.—Blanking dies for typewriter type bar.

bar, punching out the center to lighten it, and piercing the central holes for connecting the mechanism by which the type bar is operated when assembled in the typewriter.

A detail of the blank is presented in Fig. 28. This drawing with the several blanks seen in the foreground of Fig. 27 shows clearly the unusual form of this type bar.

Referring to Fig. 28 it will be seen that the type bar blank is 3.685 in. long over-all, has a height of 0.90 in. and a height over the rear lug of 1.050 in. The greater portion of the stock in the middle of the material is

punched out to lighten the blank and this is done at the same operation as the blanking and piercing of the small rivet hole.

It will be noted in Fig. 27 that little waste is made in blanking these bars. The upper and lower dies are made in two sections, the dividing line being along the central hole in the blank. The dies are of the compound type; the lower member carries the outside blanking punch and the upper die carries the piercing punches for cutting out the interior of the blank. The top die is fitted with a shedder that forces the blank back into the scrap strip on the up-stroke of the press. When the stock feeds forward again the strip carries the blank with it. The next down-stroke of the press causes the projecting member at the front of the upper die, Fig. 27, to strike the blank, which is still retained by the scrap, and knock it out of the strip into a box.

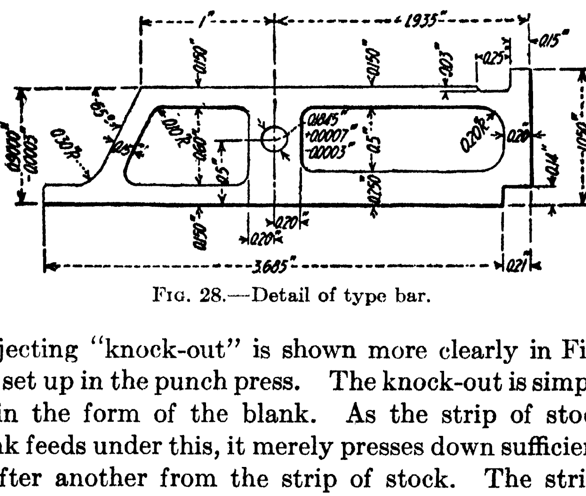


Fig. 28.—Detail of type bar.

This projecting "knock-out" is shown more clearly in Fig. 29, where the tools are set up in the punch press. The knock-out is simply a block of steel made in the form of the blank. As the strip of stock with the inclosed blank feeds under this, it merely presses down sufficiently to press one blank after another from the strip of stock. The strip is carried through the machine, where it is broken up into comparatively short strips of scrap.

The blanking portion of the lower die is supported by springs and is normally flush with the face of the die, as indicated in Fig. 27. The centers of the blank punched out (see Fig. 28), when punched down through the blank, fall through the holes in the lower die and out of the press at once, without being carried along by the stock. The arrangement of these supporting springs under the lower die, as well as the construction of the shedder for the top die, is of conventional type and needs no special description. It may be pointed out, however, that these tools are of heavy general construction, and the blocks on which they are mounted are equally well proportioned. The material handled is 0.028 in. thick and is tempered bandsaw steel, so that the material puts considerable work on the tools for the blanking of the type bar. It will

be seen from Fig. 29 that a heavy type of press is used to operate the tools.

Following the blanking operation, the type bars are flattened and thus straightened from end to end. They are then ready for grinding to width and to length and to bring the front or working face truly perpendicular to the guiding bases, bottom, and top.

In the blanking of these type bars about 0.010 in. is left to grind off—0.005 in. on each edge. Similarly, about the same amount is left at the

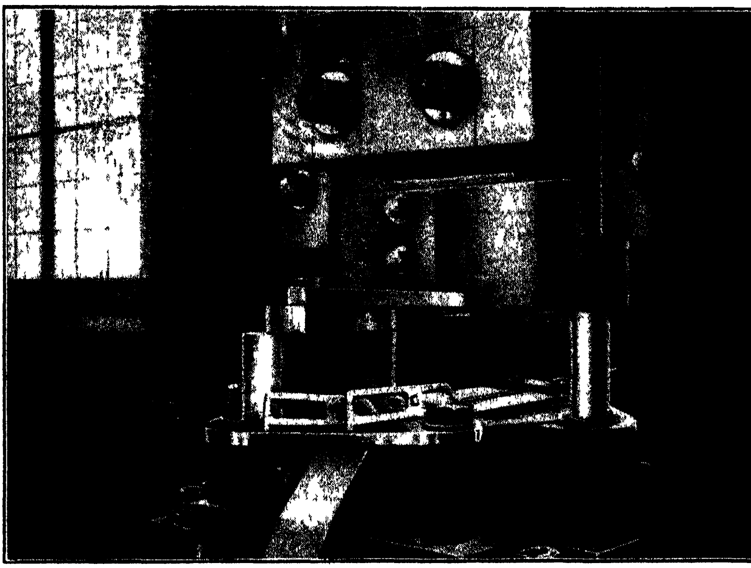


FIG 29. Type-bar tools in the press.

front end to assure this coming square with the upper and lower edges of the bar. The blanks are handled on the grinders, 130 of them held at a time in a single fixture, so that they are really ground exactly as a solid block of the same area would be gone over by the abrasive wheel.

The fitting of the type to the end of the type bar is an important operation, involving some interesting methods and fixtures.

There is, however, one more point to this operation which it may be well to describe in connection with what has gone before in reference to making these type bars—namely, the piercing tools for the three holes at the front end of the type bar, to receive the rivets for later fixing the type in place. The piercing tools, Figs. 30 and 31, used in conjunction with the tools for making the corresponding holes in the type body proper, assure the type being so fixed upon the end of the type bar that it can never be displaced or loosened in any manner.

The method of nesting the work will be apparent, as it is here shown with the lower, or bearing, edge pressed against the stop guide at the back

by the two spring punches QQ, which apply sufficient pressure to hold the blank in nest A, and against the top surface without likelihood of springing. The endwise position of the work relative to the dies is determined accurately by the slide R, which is pressed forward against the action of the pressure spring by the taper plunger J carried by the punch block. In Fig. 30 this punch block is seen descending, and the taper plunger is about halfway down. Just before the piercing plungers have reached the

FIG 30—Piercing holes in end of type bar

work, the taper plunger brings a straight portion of its body against the rear end of the slide R, Fig. 31, holding this in position and consequently holding the work at the exact point for piercing the three holes at a definite distance from the front, or working, end of the type bar. This position, being the work of the combination slide R and the plunger J, is further aided by the pressure pad H, which is forced down on the work and holds it steady during the lift of the punches.

The arrangement of the three piercing punches is shown clearly in the elevation, Fig. 31. They consist of drill rods turned down at the end to form a light punch and have a head at the rear end to retain them in their guide bushings. The latter are fitted securely in the punch carrier and are long enough to give the piercing punches proper support for the

greater portion of their length. Immediately behind the head of the piercing punch is a short plug about $1\frac{1}{8}$ in. long, of $\frac{1}{4}$ in. diameter, and behind this is the head of the screw. It is therefore an easy matter to adjust the punch to strike the work at the desired instant, and the three punches can be staggered for giving the shearing action as desired.

The method of setting the guide bushings will be apparent upon inspection of the plan view and the accompanying elevation, showing the two members of the press tools, Fig. 31, so that little further explanation will be necessary. These tools are, of course, guided by pillars, so that they are operated similarly to sub-press tools.

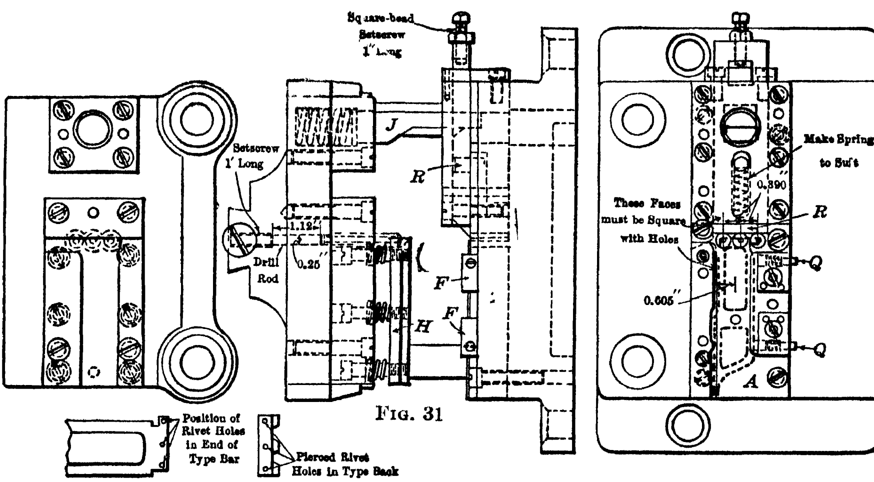


FIG. 31

FIG. 32

FIGS. 31–32.—Dies for piercing rivet holes.

Referring to Fig. 30, an interesting gaging device is shown at the right upon the stand, this being the test gage, not only for the accuracy of the type bar itself, but for testing the placing of the rivet positions relatively to the front end and to the bottom of the bar. This gage has a nest at the top, made to accurate outlines to correspond with the blank itself and with location holes corresponding to the rivet holes and the larger holes pierced near the center of the type-bar blank. This nest is formed on the top of a pad that operates against spring pressure. The test is to place the blank upon the nest pad and push the whole thing down to see if the outer edges at the bottom and ends will just slide past the corresponding shearing edges of the test-gage body. This corresponds closely to what might be called the thumb-nail test, as commonly applied in the case of a flush pin gage, where the thumb nail is passed over two edges supposed to be flush and where a fraction of a thousandth discrepancy is easily detected if there is any lack of uniformity. Such is the case

here. If the end of the type-bar blank or if the lower edge should project at any point by even 0.0001 in., this would interfere with the punches descending if pressed lightly with the finger.

The piercing tools for the type take care of all of the type for the machines and must therefore be adaptable to conform to the various angles to which the bodies of the type are milled in relation to the printing faces of the characters. In Fig. 32 a sketch is reproduced showing the position of the small rivet holes in both type bar and type, and in Fig. 488

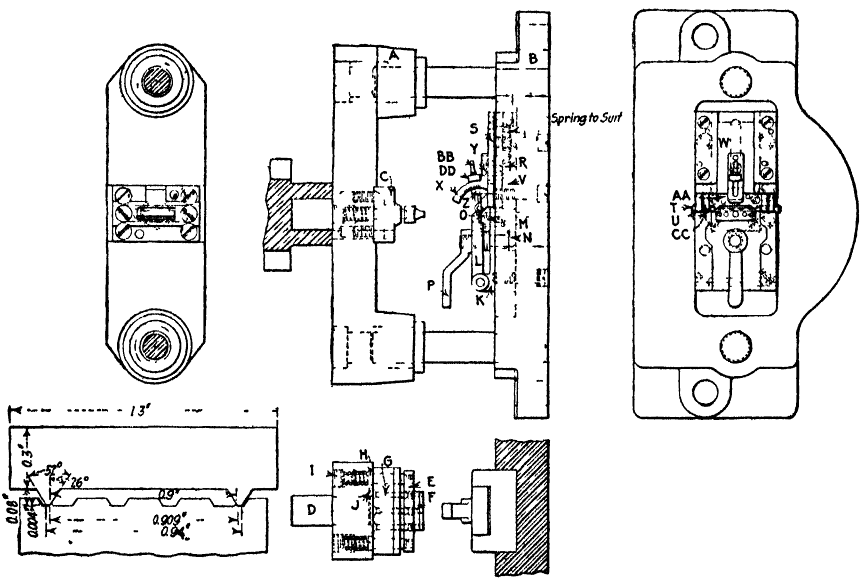


FIG 33.—Details of type-piercing dies.

is a detailed drawing of the dies for piercing the holes in the type. The adjustable locator *DD* takes care of all angles of type and the work is held securely in its nest by the clamp *B*. It is not essential to enter into a detailed description of this die but its features are called attention to, as worth study by those designing adjustable tools for various classes of work.

The dies are shown in operation in Fig. 34.

The important part of many riveting undertakings is not the actual riveting process but the preparation in the piercing of the holes for the rivets. The riveting tools are as a rule very simple devices, many examples of which are included in the half tone, Fig. 34, in Chapter I. With holes properly pierced so that they aline and with suitably formed rivets the riveting dies present no difficulties in making or using. For various examples of different shapes of riveting tools the reader is referred back to the above illustration.

A Set of Riveting or Staking Tools

The three steel parts in Figs. 35, 36, and 37 are members of a coin wheel that are made in the dies, Figs. 38, 39, and 40, and assembled and riveted or staked by the tools in Fig. 41.

The blanking dies in Figs. 38 and 39 are of simple form and the blanking and piercing tools for the disk, Fig. 37, are of the progressive

Fig 34.—Piercing for type rivets.

type as shown by Fig. 40. The long blank, Fig. 39, is bent up to the outline, Fig. 36, by the hand forming tools at the right in Fig. 39. The tools by which the parts are fixed together in Fig. 41 are made up of a base *A* with an open nest for the dial which rests therein after the riveting lugs on the other members have been placed into the pierced slots in the disks. The partially assembled wheels are shown in front of the tools and the arrangement of the riveting punches in the holders will be understood from the engraving. These punches are made with V-shaped points to strike the end of the lugs and spread them sufficiently to hold the parts

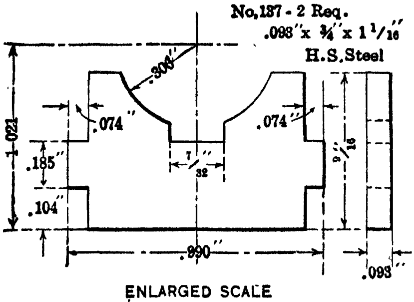


Fig. 35.—Spacing piece for a coin wheel.

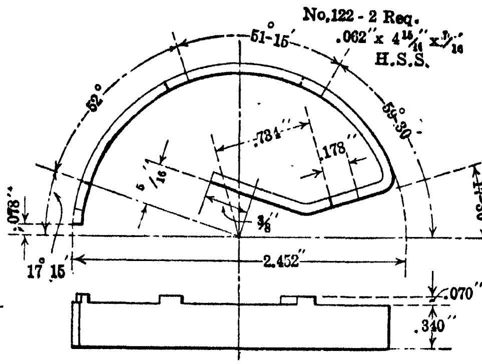


Fig. 36.—Coin wheel member.

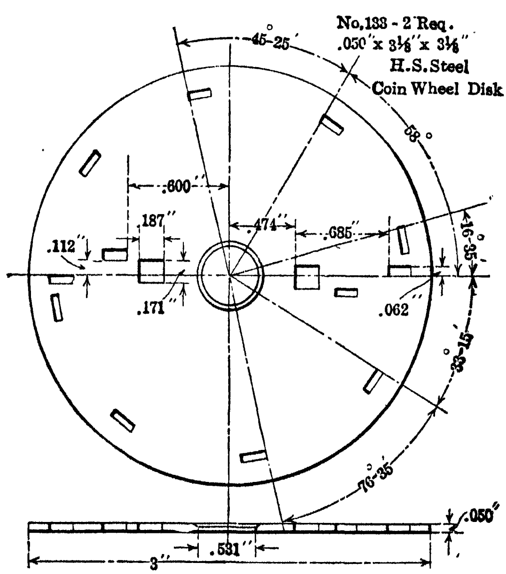


Fig. 37.—Coin wheel disk.

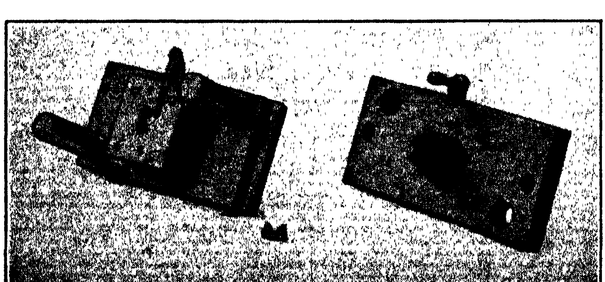


Fig. 38.—Blanking dies for piece Fig. 35.

together. The punch holder carries a pressure pad B to hold the work while the operation is performed.

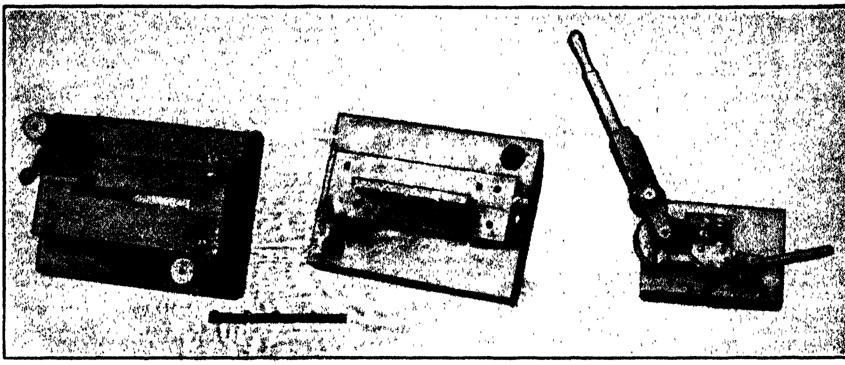


FIG. 39.—Blanking and bending tools for work in Fig. 36.

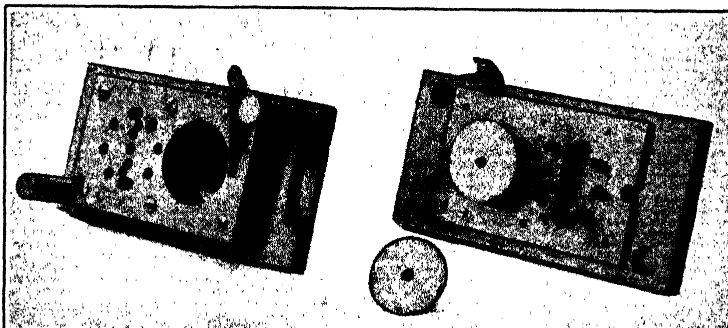


FIG. 40.—Blanking and piercing dies for coin wheel disk Fig. 37.

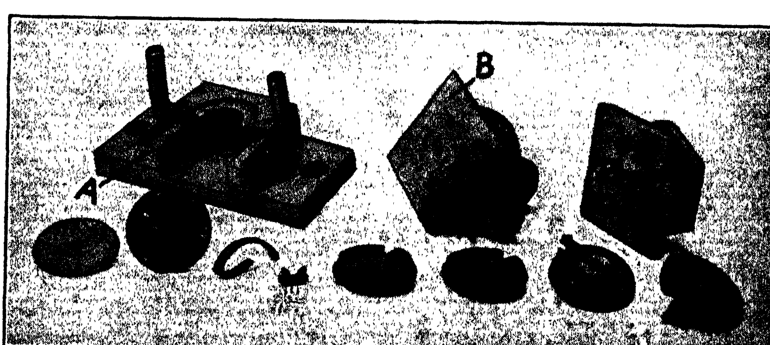


FIG. 41.—Riveting dies for coin wheel.

SWAGING DIES FOR AN AIR RIFLE PART

The die shown in Fig. 42 was made for producing the shot seat A, Fig. 43, for an air rifle. Brass tubing is used $\frac{1}{4}$ in. outside, a little under

$\frac{3}{16}$ bore and the washer hole is made slightly over $\frac{1}{4}$ in. With a circular saw the tubing is cut $\frac{37}{64}$ in. long and then the pieces are tumbled. As can be seen from Fig. 42, the die upsets the wall of the tube, increases and tapers the outside diameter, and forms a choke bore about $\frac{11}{64}$ in., leaving the outer end tapered to hold the shot; besides throwing up a bead at B and turning over the lower end, thus securely seating the tube in the washer.

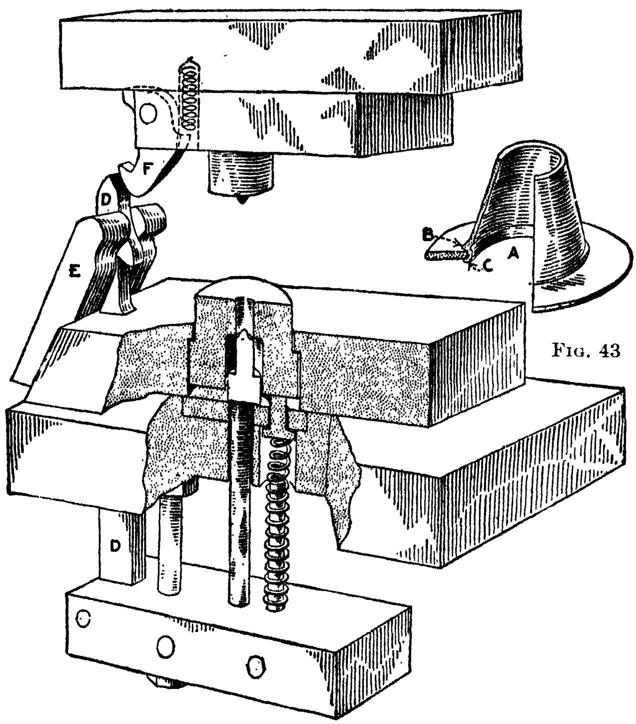


FIG. 43

FIG. 42

FIGS. 42–43.—Swaging dies.

The construction of the die is shown in Fig. 43. The springs hold up the die and also return the knock-out. In operation the washer and the tube are assembled and placed in the die, the tube resting on the knock-out pin, which also acts as a mandrel to form the funnel-shaped mouth, and the washer resting on the die. The $\frac{1}{8}$-in. motion of the die keeps the washer in the right position on the tube while the latter is being upset. The die is countersunk at the top to form the bead over the washer.

On the down-stroke the dog F swings in and passes E and D, but on the up-stroke it engages the hook D and pulls out the finished piece; as F is wider than D, E pushes it out of engagement with D. The die being tapered, the only resistance that the knock-out has to overcome is right at

the beginning of the pull, when the dog is in full engagement with the hook. At the point of release the only stress is from the pair of light springs, so that the wear on the points is nominal.

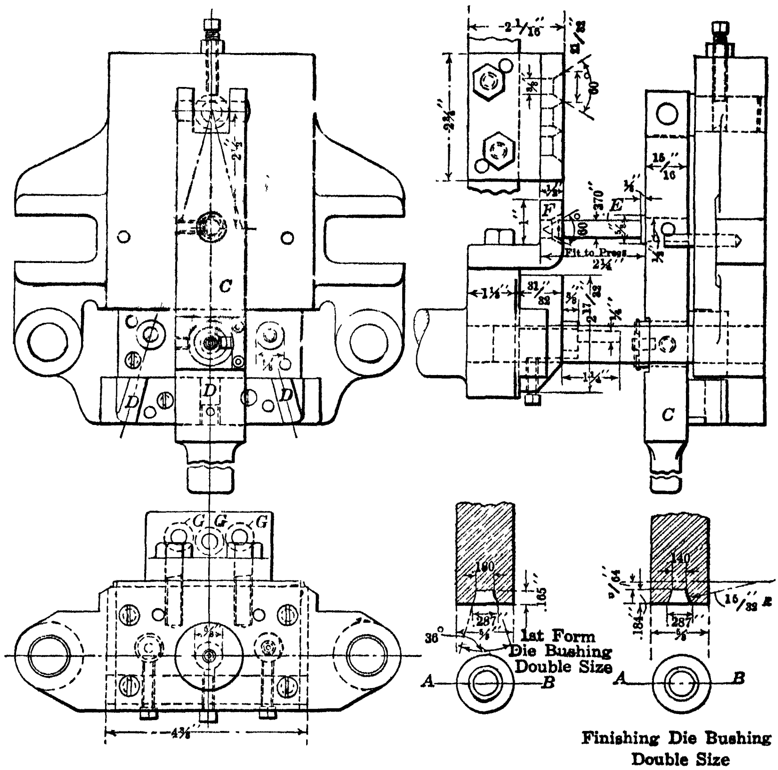


Fig. 44.—A forming die for a brass tube.

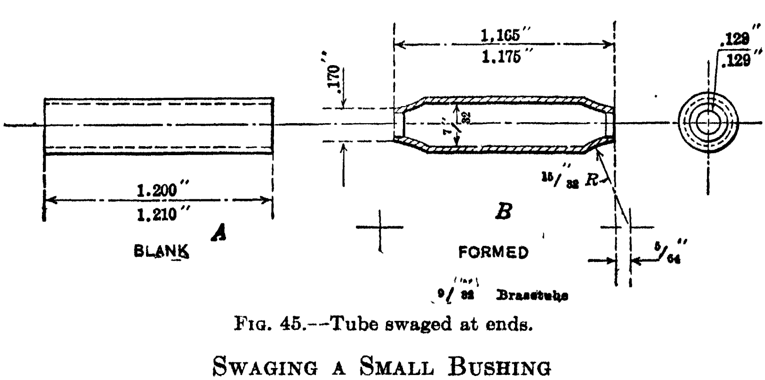


Fig. 45.—Tube swaged at ends.

Swaging a Small Bushing

The dies in Fig. 44 are for swaging or forming the ends of the small tube shown in Fig. 45, where *A* is the blank and *B* the swaged product.

The drawing, Fig. 44, shows two dies for swaging down the tube ends. The first gives a straight taper, the other forms a curved end. The work is placed in the swiveling holder *C* swung to the right for the swaging of the taper end, moved to the center for the next blow which swages the curved outline, and then swung to the left for the knock-out punch to push the work down out of the dies. The swinging holder *C* has a locating tongue to fit the index slots *DDD* at the front of the die base. In addition, alinement with the upper dies is assured by the cone pointed pin *E* which enters a guide hole in the bracket *F* attached to the rear of the upper head. There are three of these guide bushings, as shown at *GGG* in the plan view. They are, of course, located upon an arc struck from the same center as the pivot which carries the swinging work holder *C*.

CHAPTER XVIII

INDEXING AND TRANSFER DIES

Indexing and transfer dies are used for many classes of press work, the indexing type being especially applicable to notching, perforating, and similar operations where press runs are rather limited in volume. Transfer dies, on the other hand, are usually suited to long runs where the cost of second operations and feeding by hand into nests is avoided by some form of mechanism for carrying the blank from one operation to the next by the action of the press itself.

An early form of transfer mechanism was built into the cartridge loading presses designed years ago. The cartridge cases were carried from one position to another and under one punch after another by an indexing dial which brought the work accurately under the series of tools including several punches, powder charger and bullet placing punch, until the assembled cartridge was discharged into the tote box at the side of the crimping die.

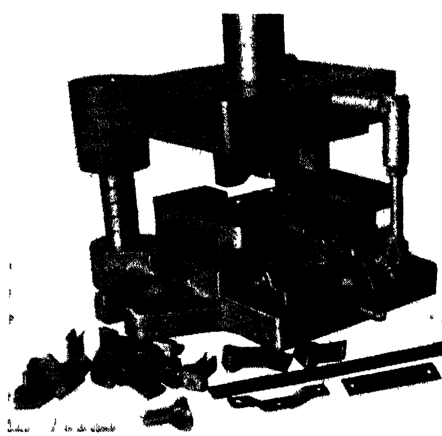


FIG. 46.—Dies with transfer movement

This device was distinct from the ratchet-operated feed dial for drawing presses which consists of an indexing dial for carrying a cup under a redraw punch. The work of this latter dial is feeding solely to the drawing punch. No transfer takes place to any other punch.

Transfer devices—usually built into the dies themselves—may be for carrying work by some form of dial (as indicated above) from one station to another, or they may move the work laterally or in an arc from one point to the next in the series of operations.

The dies in Figs. 46 and 47 have a built-in device for moving a cut-off blank from front toward back by the operation of a rocker arm and slide which are actuated by the up-and-down movement of the punch head.

The work produced is a narrow clip of heavy gage metal which is sheared and pierced, as at *A*, at the first stroke, then formed with the

depression at the center at the second stroke, then bent U-shaped to bring the jaws together in the third stroke, after which a completed piece *C* is dropped out of the press at each stroke.

The cross slide in these dies is reciprocated by the flat-ended rocker which is returned against the lift of the punch-head connection by the coiled spring at the front arm of the rocker. A stop screw under the front end is adjusted to limit accurately the return movement of the slide. The forward movement is similarly controlled exactly by the setting of the connecting-link adjustment on the punch head.

With reference to the open view in Fig. 47, the position of the punch-head tools will be clear. The three piercing punches and shear punch

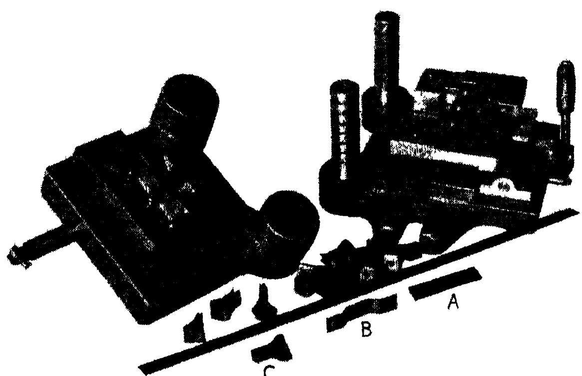


FIG. 47.—Dies in Fig. 46 taken apart.

are in the same row; next in position is the first forming punch by which the offset middle portion of the blank is formed; then the bending tools which fold the jaws of the blank down, over and around a triangular-shaped horn. The work is slid back from stage to stage and finally out of the dies by the action of the slide carrying the cut-off blanks one by one toward the rear into successive operations.

A few typical forms of indexing devices as incorporated in the dies themselves are illustrated briefly in the present section. The first of these is shown by Fig. 48 which represents a notching device for disks for electrical work. This is one of the commonest forms of indexing die, as numbers of similar tools or dies operated on the same general principle are used for this class of work.

This particular set of dies pierces three slots at each stroke, the punch being a triple device as indicated. It might, however, be a single punch, or the holder might carry more than two or three according to conditions. So far as the punch is concerned, it may be stated that it carries a stripper

which is backed up by a rubber buffer, and the punch sections are let into a steel holder which is made with a round shank to fit the slide.

The die is located at the front side of the indexing dial, and the latter is in the form of a ring with gage pins which enter notches in the edge of

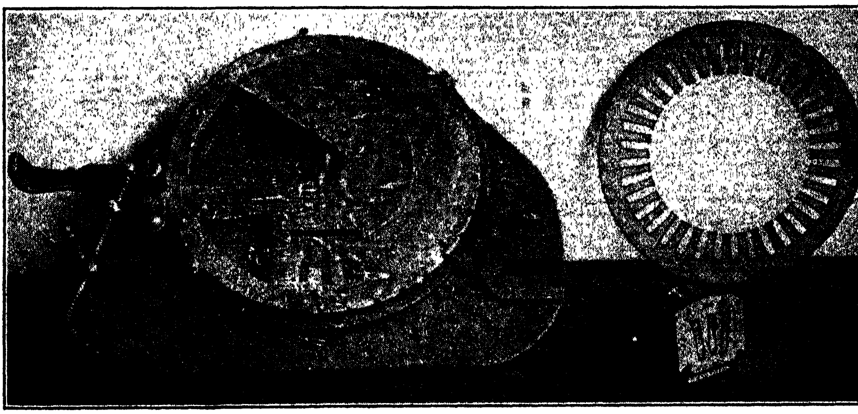


FIG. 48.—Indexing die for notching disks.

the work to locate the disk and cause it to rotate when the index ring is advanced by the ratchet teeth and pawl at the side. There are two pawls at the left side, one for feeding the ring ahead, the other for locking it

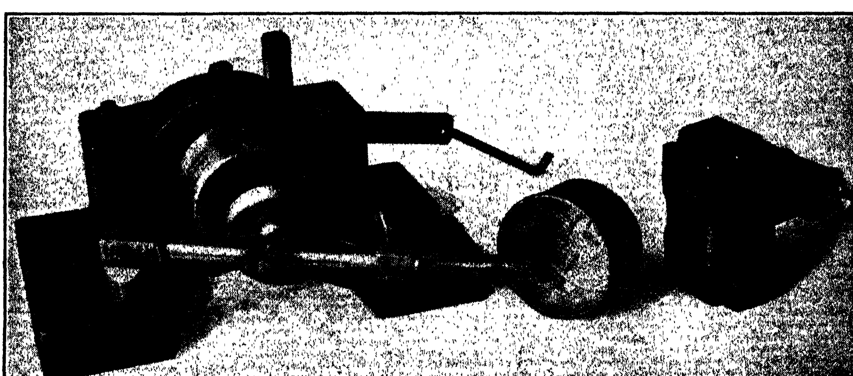


FIG. 49.—An indexing perforating die.

against backward movement when the feed pawl is being swung to the rear, preparatory to giving the indexing ring its next forward movement.

AN INDEXING PERFORATING DIE

The indexing tools in Fig. 49 are for perforating the aluminum article at the center, through the side walls, with groups of small openings, numbering 48 holes in a group and 16 groups or 768 holes in all. The

punches are placed, 48 of them, in a punch plate fitted to the holder at the right and a close fitting stripper is mounted on the holder in the manner indicated. The work is shown in place on the index plug in Fig. 50, and in Fig. 51 the method of arranging the punch holder to actuate the index mechanism will be seen.

The bottom of the work has been perforated in an earlier operation and here there are three pins in the end of the index plug that enter three

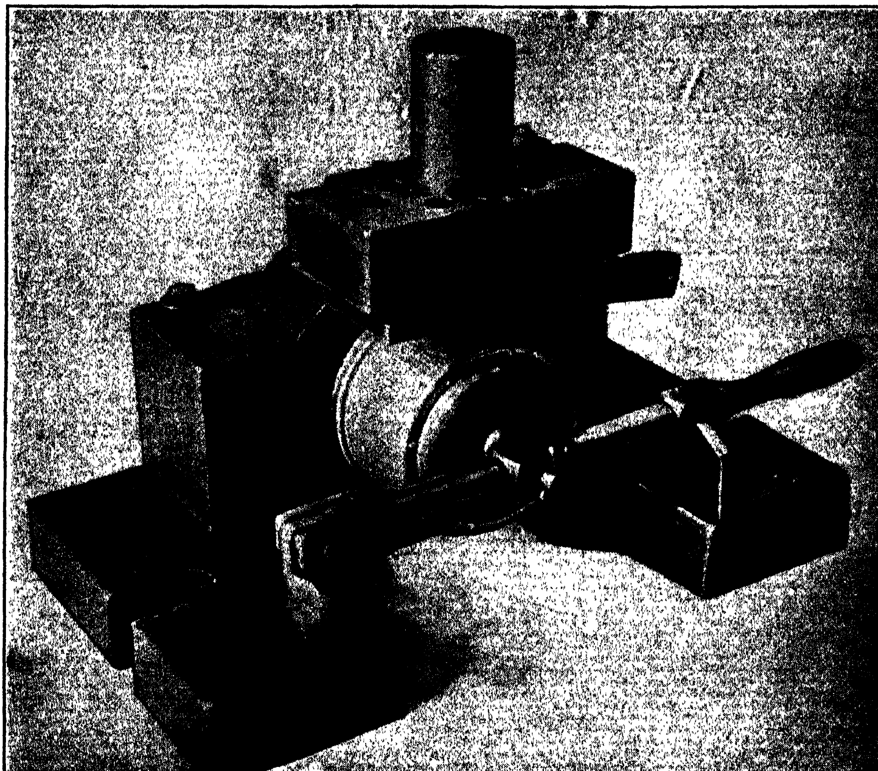


FIG. 50.—Indexing die with work in place.

holes pierced in the work and act as drivers for the piece. The lever at the front with the large disk attached is swung around and latched as in Fig. 50 to hold the work on the fixture. The die is in the form of a horning die with diameter to fill the cup and the outer shell fixed to hold the die which is fitted into it along the top center line. The rotary part is an internal plug or arbor that carries the three driving pins as described before.

When the ratchet wheel is actuated by the pawl at the rear, Fig. 51, the arbor with the work is rotated ahead one notch and the work thus brought into place for the piercing of a fresh group of holes. The pawl is

carried upon a slide at the back which is actuated by the up and down movement of the press. A stop pin in the face of the ratchet wheel acts to release the feed pawl upon the completion of one revolution of the work.

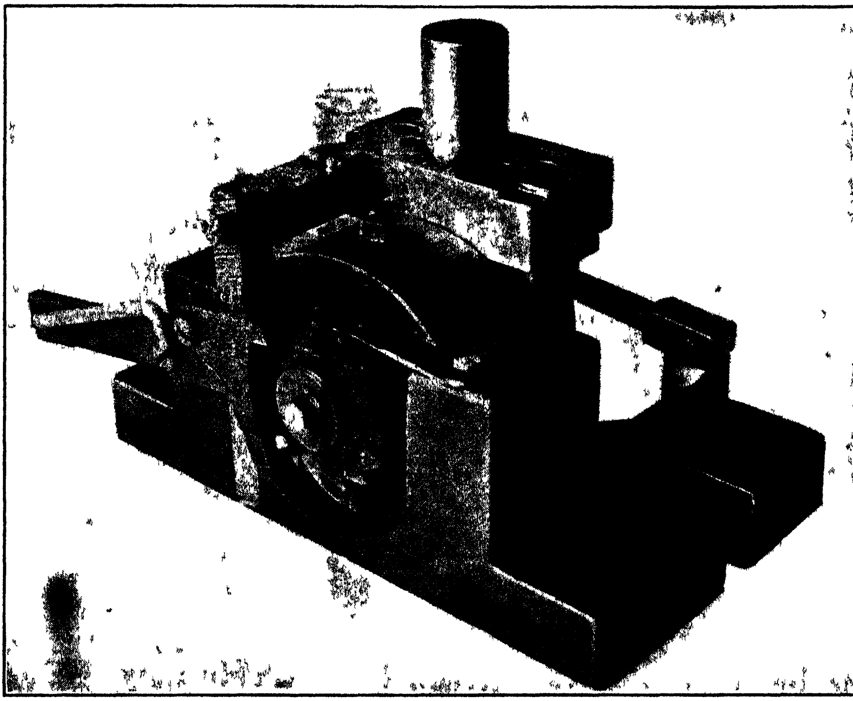


FIG 51 – Mechanism at rear of indexing die

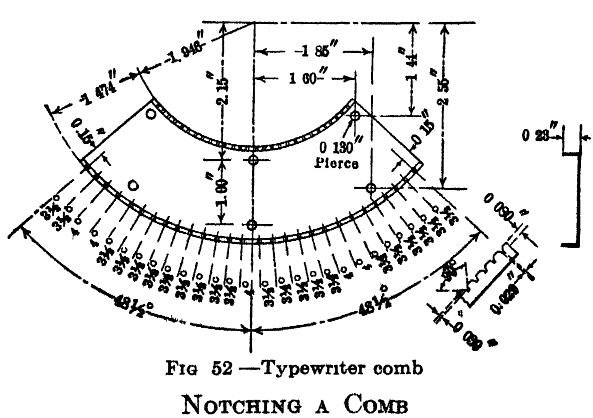


FIG 52 —Typewriter comb

NOTCHING A COMB

The detail in Fig. 52 represents a typewriter comb which is notched in the indexing die shown by Figs. 53 to 56. The work is made from phosphor bronze 0.032 in. thick and is bent up to a circular channel with

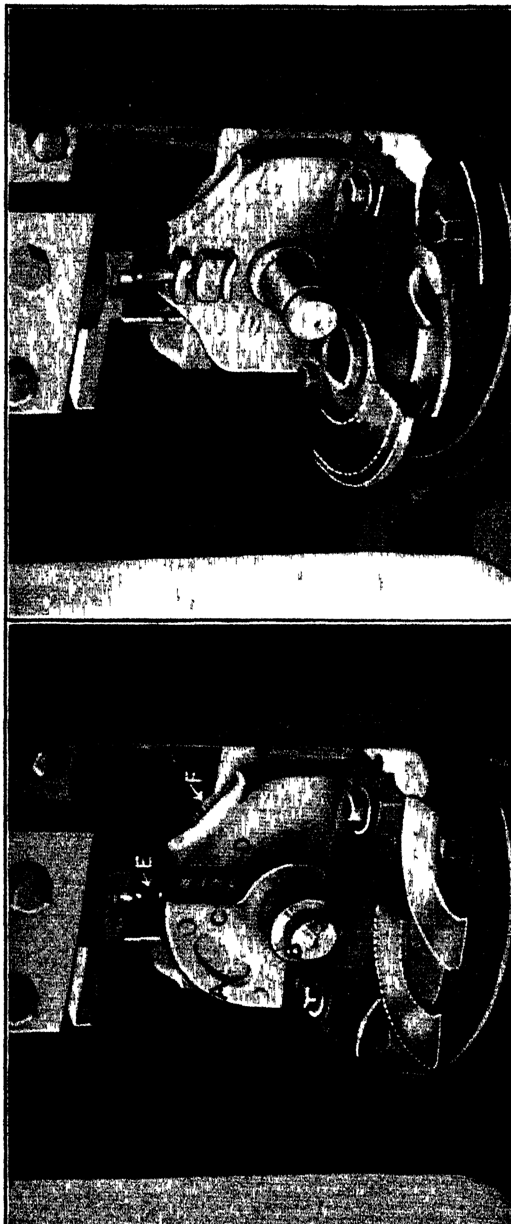


Fig 53 Fig 54

Figs 53–54 —Indexing die for notching a typewriter comb

an outer radius of about 3½ in. There are 28 notches cut in the flanges around this arc shaped piece and these are spaced in accordance with the angular measurements given on the drawing.

The indexing fixture is shown clearly in the photographic views, the first of these, Fig. 53, illustrating the working face of the holding fixture

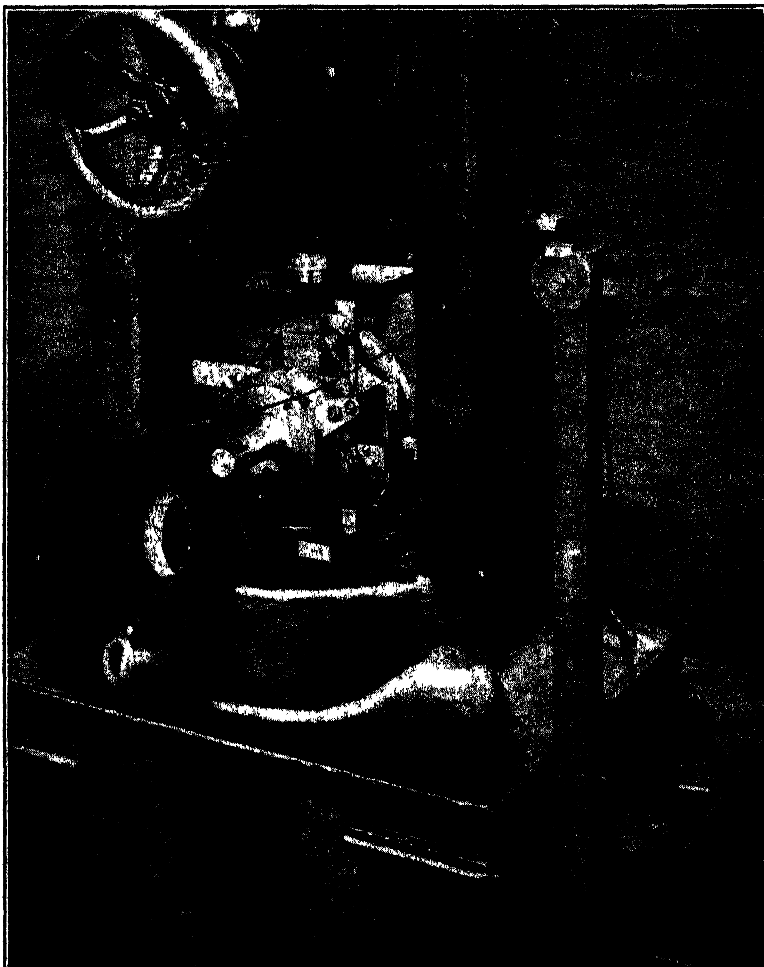


FIG. 55.—Rear of notching die.

in position on its spindle and the machine ready for operation. The appearance of the comb before and after this punching operation is well brought out in Fig. 53, while the principal dimensions are included in Fig. 52. The details of construction of the fixture are shown in Fig. 56. The general method of operation will be obvious upon examination of the various illustrations.

Referring to Fig. 54, which shows the work-holding plate removed, it will be seen that the inner face of this plate is provided with a seat in the form of an arc, into which the work is slipped and in which it is located endwise by suitable stop pins that hold it in place. When the work

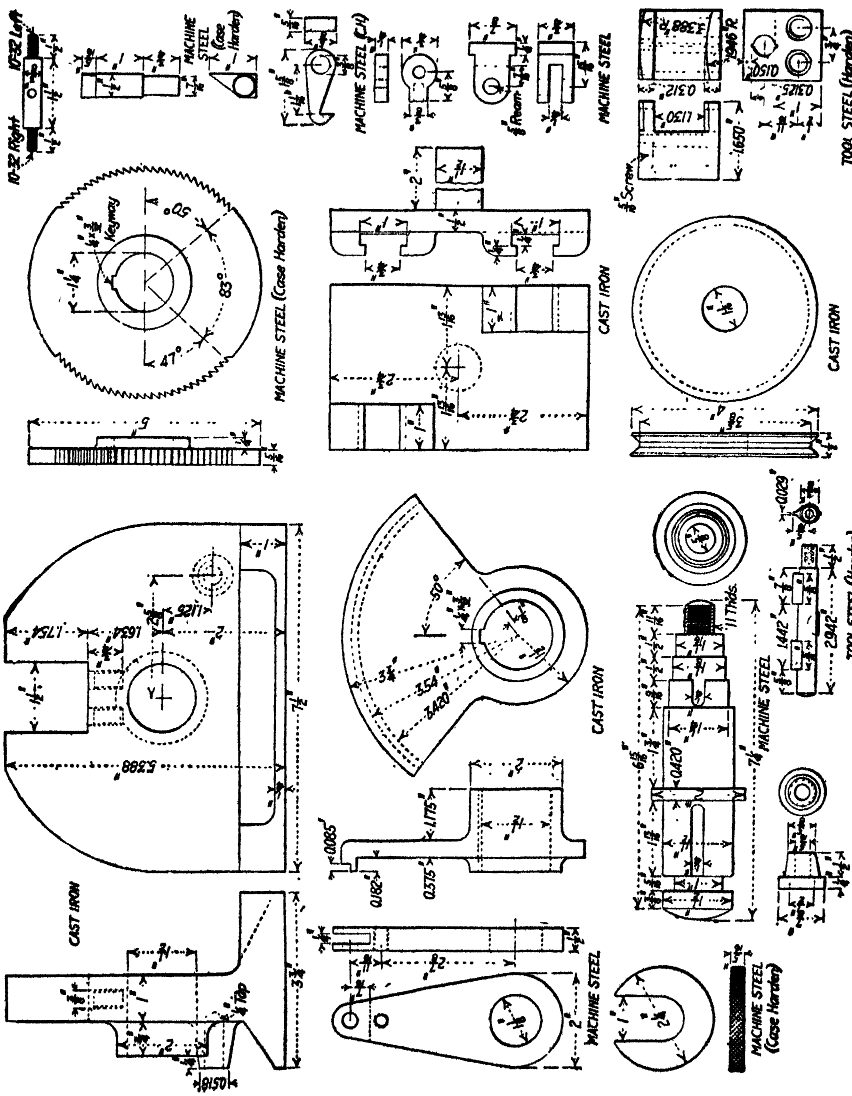


FIG. 56.—Details of comb-notching die.

plate, *A*, Fig. 53, is put back in place on the spindle, it is held against longitudinal movement by the open washer *B*. This slides into a slot in the circumferential groove near the end of the spindle and the projecting flanges of the work, which are to be notched, rest upon the curved surfaces

at *CD*. These are more clearly seen in Fig 54 which shows the work-holding plate removed

The punch *E* is a cylindrical body with two cutting teeth inserted at proper distance, one above the other, to operate upon the two flanges simultaneously This punch is illustrated in Fig. 54. At the left of the punch will be seen the mechanism to operate the pawl by which the ratchet wheel at the rear of the fixture is moved upon the up-stroke of the punch. This advances the work one space farther ahead for the cutting of the next pair of notches, on the next down-stroke of the press. The arrangement of this feed mechanism will be more clearly seen in the rear view, Fig 55. It will be noticed from this and from the details in Fig 56 that the ratchet wheel is provided with two sets of teeth on opposite edges. The fixture answers for both upper and lower combs by changing the ratchet wheel

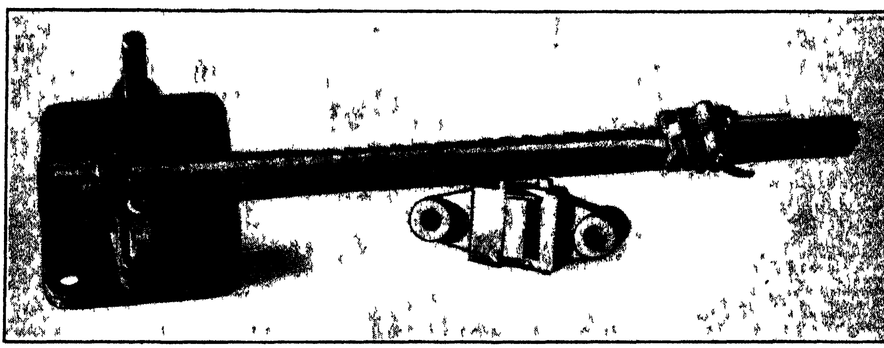


FIG. 57 — Dies for graduating a straight bar.

The details of the punches also are shown in this drawing along with the guide and supporting blocks for the curved edge of the work. The details show also the form of the spindle for mounting the work and operating fixtures, as well as the various smaller parts that enter into the construction of this device.

It should be noted that the work-holding fixture, which is in the form of a quadrant, is made with a long hub to pass over the spindle. Although this is easily slipped into place, the bearing is sufficiently long to give it a firm position upon its support. This makes the notching process free from chatter and during the indexing the work is held steady for the punching stroke.

The punch holder is novel in construction in that it is provided with cross slots to receive the flange on the head of the punch and allow the punch to be adjusted as required. Similar means are used for mounting the plunger that operates the indexing devices. This device is operated at the usual rate of the punching press, and it takes less than a minute's time to produce the complete series of 28 pair of notches.

Referring now to the punch E, Fig 53, this will be seen to be of novel construction. It has a body which is about $\frac{3}{8}$ in. in diameter and which slides in a guide of the same size. The punch body is fitted with two cutting blades, each about $\frac{5}{8}$ in. long, and spaced longitudinally 2 in. apart so that they strike the outer and inner flanges of the work simultaneously.

These cutting blades are also adapted to form the angular portion of the opening at the top of the notch, which is formed to 90 degrees so that the cutting portions of the punch are similarly made at this angle. As indicated, the punch body is provided with a Woodruff key to prevent it from twisting in operation. The sleeve of the flanged head for securing the punch in the punch holder is made to fit over the neck on the punch and is connected thereto by a screw, so that it cannot be mislaid.

The tools in Fig. 57 are for indexing a straight bar while numerals and graduations are stamped upon its surface. The punch operates in the usual fashion over the die and the work which is attached to the sliding carrier on the ratchet feed bar extending from the face of the die shoe, is fed forward a definite distance each stroke so that it assumes the correct position over the die for each graduation or character stamped upon its surface.

Transfer Devices

There are various devices on dies and arrangements for removing the work from one section to another, to obviate the necessity for the

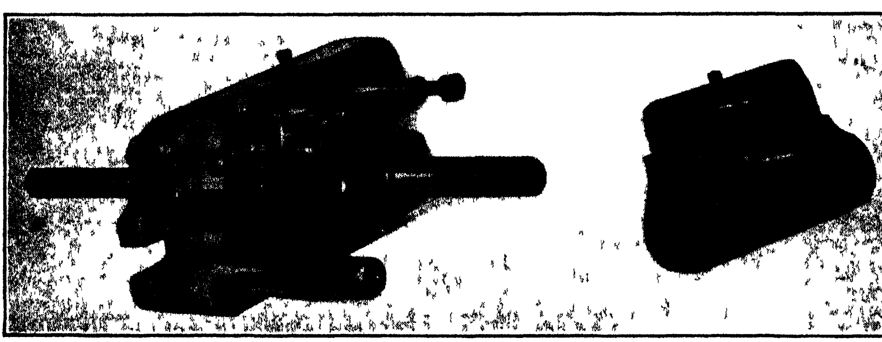


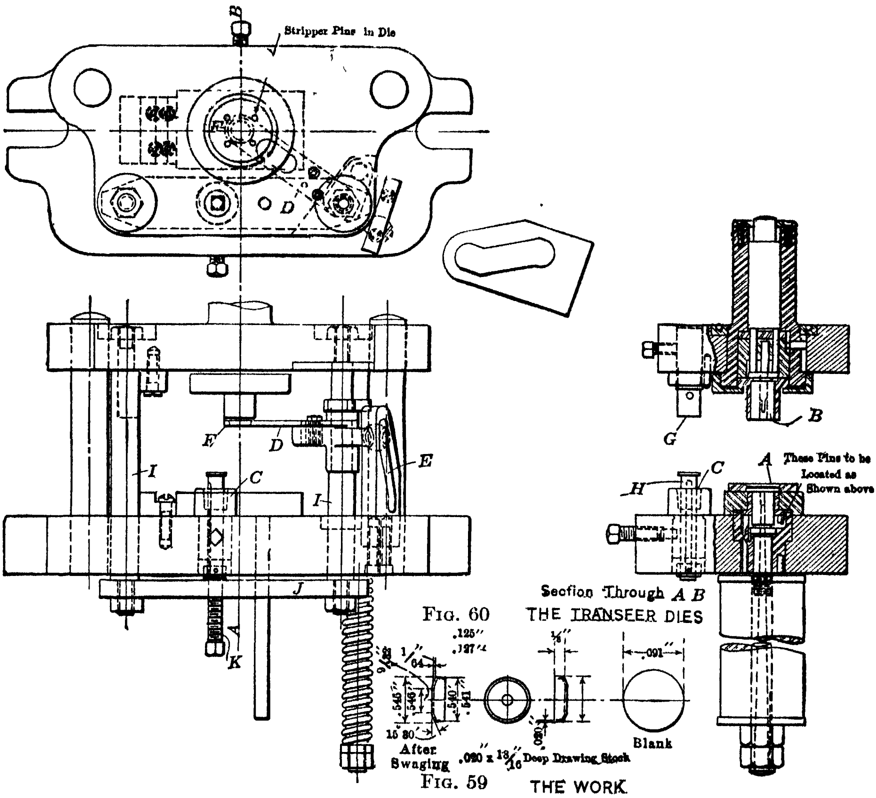
Fig. 58.—Transfer device for compound die.

operator picking the piece up with his fingers and replacing it in some other part of the die. An illustration of a set of dies arranged in this manner is shown in Fig. 58 which represents the method of blanking, drawing, and piercing a shell in a compound die and then transferring it automatically to a swaging die for reshaping the walls of the piece.

The work is shown in Fig. 59, and the construction of the tools in Fig. 60. From the latter view it will be understood that the blanking, drawing, and piercing are accomplished at one stroke in the dies A and B.

which are of the compound type and so clearly shown as to be understood without definite reference to each feature. The shell emerges from these dies with straight walls and is transferred automatically to the die *C*, in front, where it is formed to a taper as indicated in Fig. 59. The operation of the device is as follows:

When the punch head and the drawing die *B* rise, carrying the shell up with the die, the transfer arm *D* is swung by cam slot *E* into line with the



FIGS. 59–60.—Transfer dies for a cup.

die and the positive knock-out above forces the work down into the split opening in the end of the arm at *F*. On the down-stroke this arm is swung forward by the cam movement and alined with the swaging die *C* at the front of the shoe so that the punch *G* can force the work down into the tapering die *C*. The knock-out in this auxiliary die is at *H*. It is depressed by the forcing down of the shell into the die and when the punch head rises it is carried upward by the action of the bolts *II* and the cross bar *J* under the knock-out screw *K*. This clears the swaging die *C* for the reception of the next shell upon the next down-stroke of the punch.

Section VII

PRESSES AND DIES FOR LARGE PARTS

CHAPTER XIX

DIES FOR AUTOMOBILE, AIRCRAFT, AND OTHER WORK

The range of press-room operations runs from sub-press operations as described in preceding pages to very large work stamped in massive presses and dies whose proportions are constantly becoming heavier with the extension of drawing and forming operations to newer classes of work and to certain lines of products not formerly considered as suited to manufacture under any equipment then available. This applies to

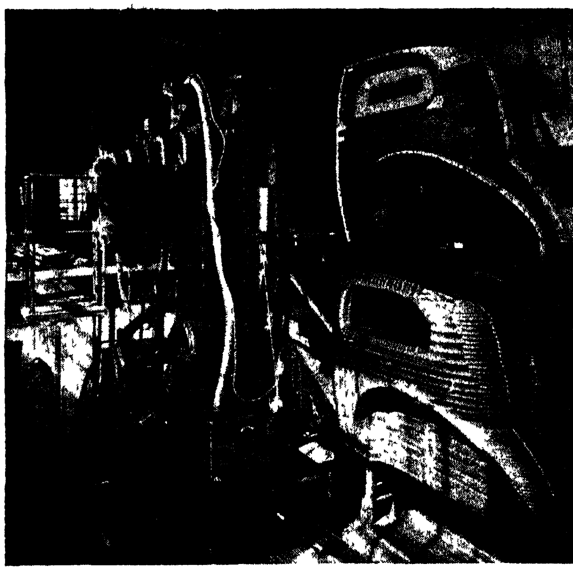


FIG. 1.—Keller tool room machine roughing out punch for automobile stamping.

automobile-body manufacture, aircraft parts, metal cabinet and furniture work, and many other lines, including deep drawing of utensils and other articles. That is, with all such lines of work the applications of the stamping process are becoming more and more pronounced, and the limits of press and die capacities have evidently not as yet been found.

The present description is illustrated by several views of big work in heavy presses and certain details of large dies, the production of which alone might form the subject of several chapters. A brief outline of some of this equipment will perhaps suffice to give a clear idea of principal features and to convey an impression of the size and character of typical work now produced under heavy press operations.

The machining of massive dies has led to development of special machine tools for the purpose, and reference has been made already to the Keller automatic tool room machine built by Pratt & Whitney for such work as the machining of big press tools. Another view of one of these machines is presented here in Fig. 1 as seen in operation at the plant of the F. Joseph Lamb Company, Detroit. The machine when photographed had just roughed out a punch for a large rear-quarter automobile stamping, and the size of the punch is clearly brought out in the view. The machine base is below the floor line in order to provide convenience of handling dies and models. The model at the top is seen with the control just withdrawn from contact. The roughing cuts on the punch are evidence of the capacity of this automatic machine for taking rapid, heavy cuts.

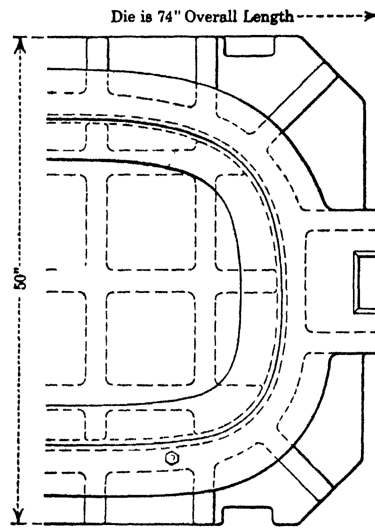


FIG. 2.—Half plan of die for auto rear-panel trunk lid.

A drawing of a punch and die from the same die shop is shown in Figs. 2 and 3. These are rear-panel trunk-lid drawing dies and measure over all 50 by 74 in. with a closed height of 35 in. Their weight runs

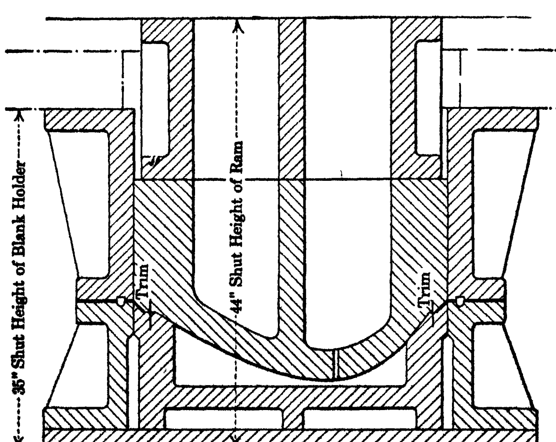


FIG. 3.—Section of punch and die for rear-panel trunk lid.

into several tons. In fact, some of these modern automobile-body dies will weigh up to 30 tons or more.

They are cast members of alloy iron usually, with steel inserts at points of wear, and all sections are massive, with thick walls and heavy ribs to resist stresses from all directions.

Still larger and heavier dies are shown in the press in Fig. 2, Chapter X, in connection with the wide range of drawing operations explained in that section.

A drawing of a die for the upper panel of a Victoria body in which production is relatively small is shown in Fig. 4. This is a die designed by the tool designers of the Seaman Body Corporation, and it is made largely of gray iron, with only a few steel inserts, and these in the draw area of the window panel, where three relief punch disks are incorporated.

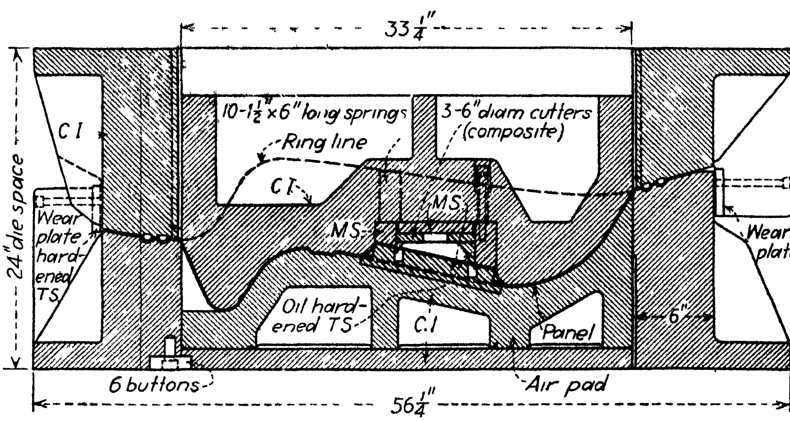


FIG. 4.—Large auto die made up of cast iron parts mainly.

This is not so much a shearing operation as it is one of puncturing the taut diaphragm an instant before it would rupture from overstretching. Restraint of the metal from wrinkling during the drawing of the window molding is by spring pressure between the punch on the die side and the spring pad on the punch side, but no attempt is made to lock the metal in the final stage of the draw.

Standard composite punch disks are employed, made of tool steel cutting edges resistance welded to wrought iron, which neither warps nor hardens during the heat treatment of the former. The thickness of the machine steel spacer behind this disk is found by trial and error as it determines the point at which rupture takes place.

Blank holder "ring lines" are developed from the "dummy" and provide for no more draw than is absolutely necessary, thus reducing the size of steel sheet required. These lines are laid out so as to eliminate any buckle or wrinkles in the free metal when it is placed on the lower ring prior to tripping the press.

This draw die operates in a double acting press with pneumatic-cushion beds.

STRETCHER DIES GENERALLY

An authority on heavy die work of the character now under discussion has pointed out that in describing the work of the die room of the preceding corporation, where the draw is shallow and the piece relatively small,

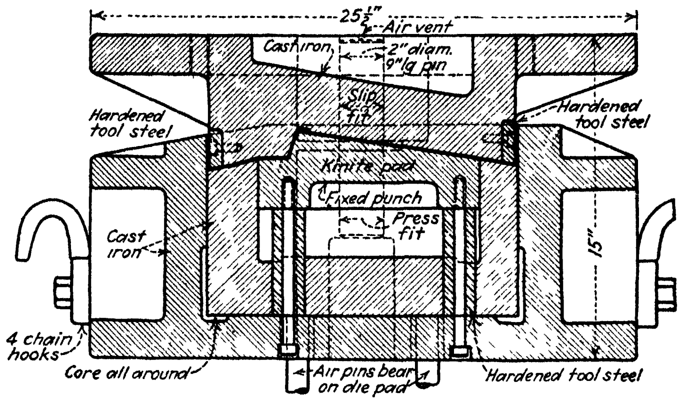


FIG. 5.—Anchoring the sheet in a stretcher die by flanging.

saving in die cost is possible by substituting a stretcher die for a compound draw die. No upsetting is permissible, however, the limitations being straight draw and embossing work. In a stretcher die, punch and die are interchanged compared with their functions in a double acting press.

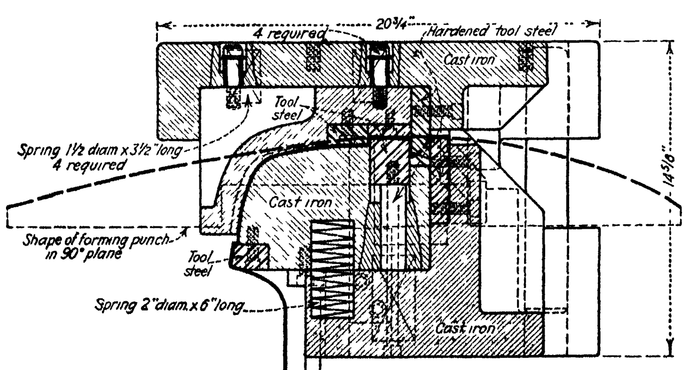


FIG. 6.—Trimming, flanging, and forming in modified stretcher die.

In place of a double acting punch are a stationary punch and a movable draw ring supported by pins from the pneumatic cushion. The lower draw-ring plate rests upon pins which extend through the main die body directly to the press air pad.

One method of anchoring the edges on a stretcher die is to flange up the sides and ends of the sheet between the punch and the outside

die shell. Figure 5 is an example of such design applied to a draw die for an instrument panel. The principle of inverting the punch and die applies. Once turned over, the edge does not slip as the flange is swept down the sides of the main die body. This die set can be finished largely with planer cuts on the sides and contour forming on the ends. The only curve finishing required is on the cast pad and its mating surface.

A modification of a stretcher die in which forming takes place over a stationary stake is exemplified in a die combining the operations of trimming, flanging, and forming the deck-opening molding on a coupe-

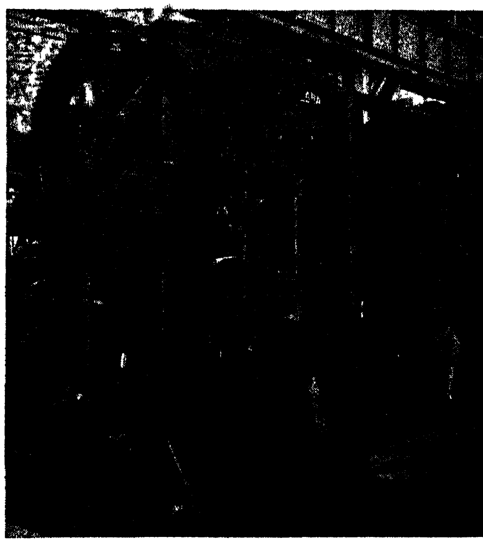


FIG. 7.—Stamping refrigerator parts in big Niagara presses.

deck side, Fig. 6. In this drawing, the dotted line shows the actual sweep of the panel and the shape of the punch member on its side. As the cross section indicates, however, all lines are straight in the other plane, allowing planer work and the use of flat tool steel face plates. This consideration is an important one, since it permits the shear edge, after grinding, to be restored to its original position through the use of shims. Another point is that the trimming punch, on its rear side, also acts as a flanging tool. The die spring pad against which the previously formed shell is held is flush with the lower punch at start and is backed by seven springs, 2 in. in diameter by 6 in. long. The hardened tool steel punch plate, over which stretching takes place, in turn is supported on $1\frac{1}{4}$-in. diameter pillars bolted to the main die base.

Other Examples of Large Work

Reference has been made to the production of large sheet elements for refrigerators, ranges, etc., and in Fig. 7 herewith is shown a Niagara

press on work of this kind. The press is a double crank unit and the work is a large sheet plate for refrigerator bodies. The operation is the trimming out of edges and corner forms and the blankingout of the center area, all as represented in the photograph.

Comparison of the height of the workmen with the proportions of the machine give some conception of the width of the press opening and the size of the dies.

A Huge Hydraulic Drawing Press

The big press in Fig. 8 is a double acting hydraulic machine designed for deep drawing and for use in forming large kettles and other cooking utensils of aluminum sheet. This 1,300-ton press was built by Southwark Corporation, Philadelphia, for the Aluminum Cooking Utensil Company, New Kensington, Pa.

The die in this press descends at high speed until it contacts the blank, then slows down automatically until the drawing has started, when it again speeds up for the drawing operation This high-speed operation is stated to prevent scoring or marring of the highly polished aluminum plate.

Fig 8—Thirteen-hundred-ton Southwark hydraulic drawing press

The over-all height of the press is 35 ft. It has a clearance between columns of 84 in. Two double push-down cylinders for draw work and a main cylinder for the maximum setting tonnage are located in the inner slide. This slide exerts a maximum pressure of 1,000 tons and has a 50-in. stroke.

THE GUERIN PROCESS ON AIRCRAFT PARTS

Briefly, the Guerin process is a simple, rapid, and inexpensive method for cutting and forming sheet materials. In place of conventional mating dies as commonly applied in power presses for stamping, drawing, etc., this process employs a single die only, a low-cost unit, and a flat, thick pad of resilient material which adapts itself to a die of any form. By pressing a sheet of metal between the die and the resilient pad, it is possible to cut and form it to almost any desired shape.

The process was originally developed for aircraft purposes, and is particularly suited to the cutting and forming of aircraft materials, such as aluminum and magnesium alloys. It is adaptable also to the lighter gages of stainless steel, and will form relatively heavy gages of mild or body steel. Moreover, certain features of the process adapt it to the manufacture of a variety of commercial products outside the aircraft field, such as, for instance, furniture, cabinets, and embossed articles.

Deep-drawing of complicated parts may be easily accomplished by this process through the use of progressive operations. Elimination of riveted stiffening members by forming sheet metal with this process into

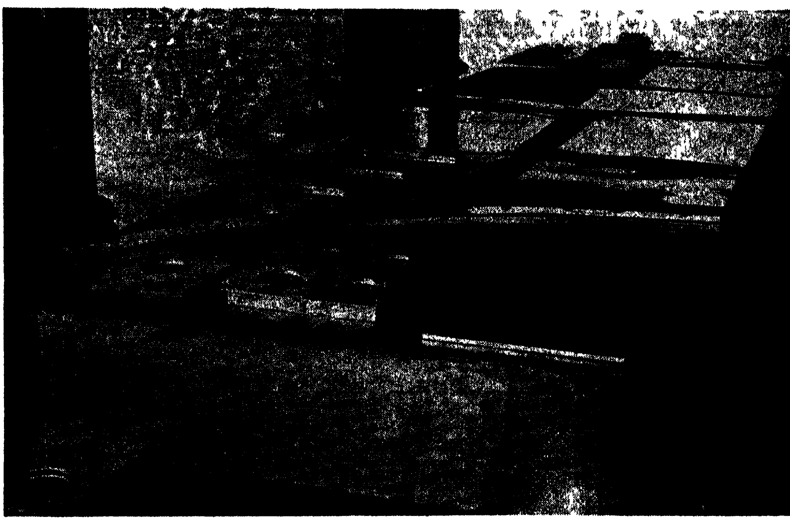


FIG 9—Method of cutting and forming sheet material by the Guerin process Typical work shown on press table

a rigid structural part greatly reduces production time and handling of small detail parts, as well as subassembly time and shop routing and inspection. Many different shapes of parts are handled at one time, as shown in Fig. 9.

Fundamentally, the process is the use of inexpensive die blocks, a rubber pad, and a hydraulic platen press for cutting and shaping sheet metal. Fig. 10 from the Hydraulic Press Manufacturing Company indicates the setup used. The rubber pad acts as a pressing medium to transmit force exerted by the press to the surface of the sheet metal, which is placed between the pad and the die blocks. Live rubber is well suited for this use, as its elastic qualities enable it to recover its original shape quickly after it has been deformed during the pressing operation. When the rubber pad is restrained and subjected to a compressive force, its elastic properties enable it to act somewhat like a fluid

and to transmit force in all directions. This action is particularly important, for in the case of forming operations it forces the metal against the form blocks. In the case of cutting or blanking operations, the action induces tensile stresses in certain portions of the metal that are concentrated at the desired places by the cutting block, and the metal is fractured or cut when these stresses exceed its ultimate strength. As shown in Fig. 10, the rubber pad is fastened within a container and the container is mounted to the moving platen of the press. This container serves to restrain the pad on all sides except the working surface. The bolster plate is fastened to the bed of the press and serves to support the die blocks.

Many cutting blocks are made from inexpensive boiler plate and tank steel. For such blocks, it is necessary to surface only the upper face to remove scale that might otherwise pit the metal to be cut. Also it is necessary to machine the vertical edges to provide a reasonably sharp cutting edge of the required shape. Composite cutting blocks have been found to be quite satisfactory. These blocks are made with a body of Masonite, or similar material, and surfaced with steel. The Masonite provides the proper thickness for the die, and the steel provides the necessary cutting edge.

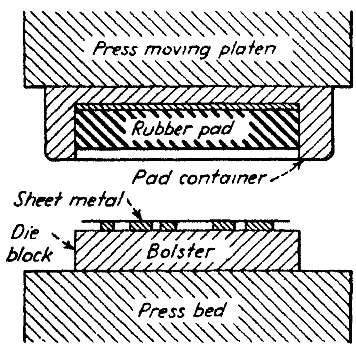


FIG. 10.—Press setup for Guerin process.

The time required actually to cut any blank or form any part is only the time required to close the press, apply pressure, and open the press. When numerous dies are used during each pressing, only a second or so of time is required for each part. Considerably more time is required to locate the stock or blanks and remove scrap after each pressing. To facilitate this work and, hence, speed production, die blocks may be positioned on steel plates or tables outside the press and may be transferred later into pressing position in a single unit.

The installation of four loading tables for a 2,000-ton press at a Douglas plant more than triples the production volume. This four-table construction is said to be a most efficient production setup.

CAST DIES FOR AIRPLANE PRESS WORK

The use of cast dies for drop-hammer work on airplane parts has been common practice, and Kirksite dies have been widely used for such operations. The Vega Airplane Company has adopted cast dies of this material, as reported by James A. Harris, foreman of their Hammer, Foundry and Press Department, for a large portion of their punch press

production. This material is an alloy of zinc with aluminum, copper, and magnesium developed to replace the zinc dies widely used for drop-hammer forming of aircraft parts. Its use for punch press operations is novel, and it is found that these cast dies are made much more rapidly and at less cost when compared with the usual steel dies and the methods of machining them.

The first dies made of Kirksite by Vega were 17 in number and involved an average labor time of 30 man-hours per die. This compares with a labor time of about 100 man-hours for identical dies machined from tool steel. It is estimated that the actual over-all time required to pro-

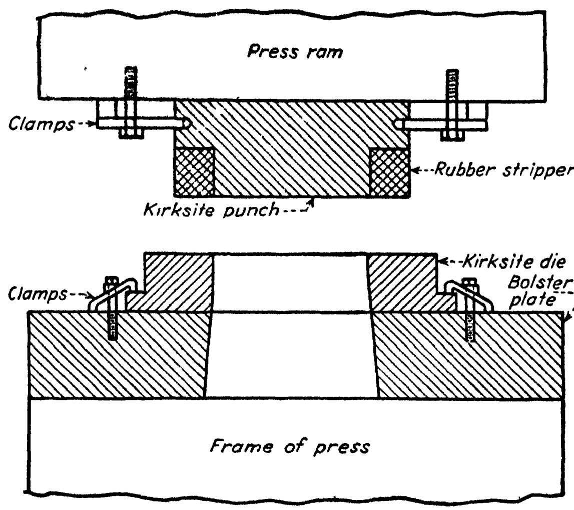


FIG. 11.—In this cast-blanking-die setup on a punch press, a rubber block is used in place of a stripper plate. The dies are cast in sand molds, and very little machining is required to finish them.

duce the cast dies may be reduced to as low as 8 hr. as compared with 3 or 4 days for tool-steel dies.

The time saved in production with these tools is illustrated by the fact that one run of the punch press produced 310 aluminum-alloy switch-box covers in $1\frac{1}{2}$ hr., compared with a drop-hammer time on this part of 15 min. per unit or four parts per hour. Limited runs of parts that formerly were made on the drop hammer, because of prohibitive costs of steel dies for punch press work, will now be shifted to the punch press.

Other economies are due to the fact that the material for Kirksite dies is less expensive, and that there is almost complete salvage of the dies since they can be remelted when worn out, whereas the steel dies cannot be salvaged except as scrap metal at a few cents per pound.

Another marked difference between the Kirksite dies and steel dies is that attachment ledges can be cast into the body of the former, per-

mitting it to be attached to the press by simple gooseneck or T-clamps. For a stripper plate on these cast blanking dies, a simple hard-rubber stripping pad is mounted around the die, as in Fig. 11. This has proved highly satisfactory.

For both forming and blanking it has been found possible to work dural 24SO and 24ST up to 0.125 in., and stainless steel of lighter gage has been both formed and blanked successfully. Compound dies have been developed satisfactorily for simultaneous forming and blanking. In some respects these cast dies are superior to steel for blanking operations. The tendency of the Kirksite to flow toward the shearing edge under pressure of the blanking operation causes the die to sharpen itself. After 1,100 parts were blanked on a Kirksite die, less burr was found on the parts than at the start of the run and the die dimensions were within 0.002 in. of the original specification.

Production of the cast dies is simple and follows a procedure well established in drop-hammer work. A pattern is made of wood or plaster and from this a sand mold is taken. The Kirksite is cast directly in this mold and little machining is required to finish the die. Although in drop-hammer work the punch is cast of lead, poured in the Kirksite female die, punch press dies are both of Kirksite. Since this metal has a relatively high shrinkage, the punch die is usually cast first, coated with a protecting material, and the female die poured around it. In this case the shrinkage is inward, and it is possible to allow for it by varying the thickness of the coating used on the punch die. In some cases both dies are made from patterns.

Machining on blanking dies usually consists of a light cut across the face of the die to produce sharp edges for blanking. The die can usually be restored after a production run by taking another light cut across the face of die and punch.

Kirksite is lighter than zinc, has several times the impact strength, much greater Brinell hardness, and six or seven times the tensile strength. The harder surface results in longer die life. When damages do occur or worn edges are to be repaired, it is possible to build them up by welding with a Kirksite rod. This cannot be done with zinc.

Maximum speed is demanded by plane manufacturers when making changes in old designs, or in placing new designs in production. The flexibility in changing old designs of blanked and stamped parts, as well as speeding production of new designs, is achieved to a high degree with Kirksite dies.

FABRICATED PRESS TOOLS

One type of fabricated punch and die is shown in Fig. 12. This is a composite construction developed at Superior Steel Products Corpora-

tion, in which the die may be almost any shape and virtually any size to suit requirements. The inner section of the die and the outer section of the punch shown both have rectangular cross sections and are cut from tool-steel plate by an oxyacetylene cutting machine. The outer section of the die and the inner section of the punch are of machine steel and are also cut out with the machine torch.

The thickness of tool steel and machine steel used in the die and punch are determined by the thickness of the stock to be blanked and the number of pieces required. The punch may be made with a solid center or with an opening in the machine steel, whichever is best suited. The die is assembled by inserting the tool-steel ring or strip through the machine-

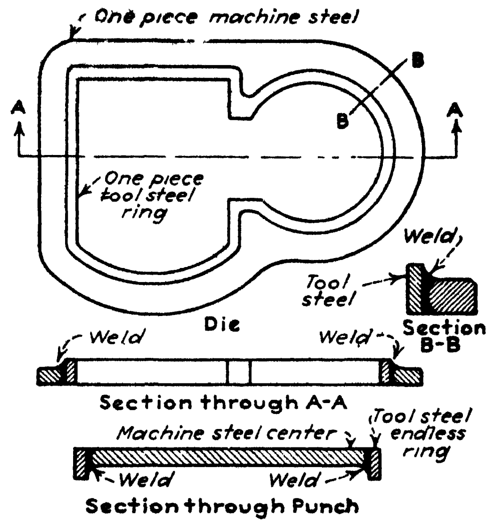


FIG. 12.—Both punch and die are fabricated from machine steel with welded tool-steel rings at the working faces.

steel supporting member; fabrication is completed by welding them together all around. The tool-steel ring or strip for the punch is placed around the machine-steel supporting center and welded in similar manner. Note the enlarged view for the welding shown in section *B* of Fig. 12. The welding extends through the entire thickness of the machine steel, forming a homogeneous unit of both machine steel and tool steel that is virtually indestructible.

A typical composite punch and die example appears in Fig. 13. The punch is shown as it appears before finishing. The die is shown after the roughing cut has been made, ready for fitting to the blank size. They are designed for blanking $\frac{5}{32}$-in. stock. Both punch and die are furnished annealed and with all surfaces ground flat. Layout can be quickly made from a template or blueprint and machining started at

once. Because of the allowance of only $\frac{1}{8}$ in., machining is done rapidly, saving much time over cutting out solid steel with the usual methods.

After machining to the proper size, the fabricated punch and die are hardened in the usual manner. This procedure hardens the tool-steel sections while the machine-steel supporting members remain relatively soft. The tool steel used for these dies is carbon-vanadium tool steel. It hardens in water at 1450°F. and produces an extremely hard cutting edge, about 62 Rockwell C scale. The amount of shrinkage is virtually uniform at 0.001 in. per linear inch. In a solid tool-steel die changes in shape resulting from hardening may be corrected merely by grinding, if

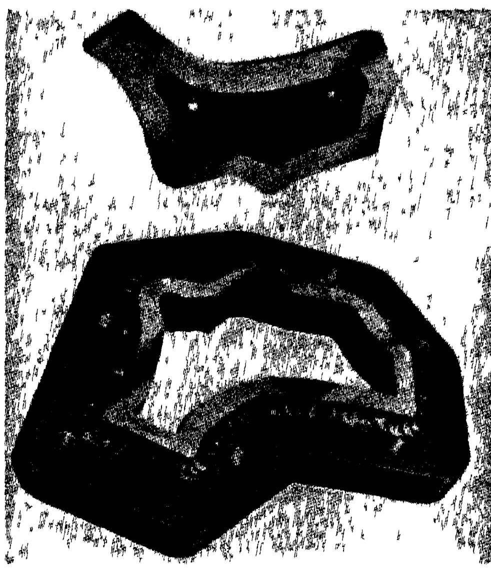


FIG 13.—Ready for finishing, the punch and die have only $\frac{1}{8}$ in of stock to be removed.

they are corrected at all. In the fabricated structure distortion may occur during hardening and may be corrected by squeezing or stretching without damage in restoring the proper shape and size.

Drilling for mounting screws and dowels is usually located in the machine-steel sections of the die and punch, since these remain soft and this work may be done after the die and punch have been hardened and finished.

Quarter-size Dies

Metal dies of either steel or Kirksite A alloy are being used to an increasing extent in the aircraft industry for large drawing and forming operations. According to John A. Cole of the Tooling Division, Douglas Aircraft Company, the development of the blank and die shapes often

requires considerable time, particularly when done full size, because of the irregular contours of many of the stampings. The practice of making quarter-size dies often saves several weeks in getting into production on large stampings.

The quarter-size dies are cast from Kirksite A alloy. They are set up on small double acting hydraulic presses, and the blanks are made proportionately thinner than the full-size blank in most instances. But satisfactory results have been obtained with full-thickness blanks.

For many blanks, a truncated cone with welded seams is used in order to obtain proper distribution of the metal and to reduce wrinkles and cracks. The shape of the cone is obtained by drawing sample blanks in the quarter-size die. This practice also permits inexpensive study of weld positions, to avoid their location at points where the metal is considerably stretched. After the blank shape and seam positions are determined, notches or pin holes are put in the blank to guarantee proper location during drawing.

When the drawing and forming problems have been solved with the quarter-size die, a full-size die can be made with assurance that little reworking will be necessary. Then full production of the required part gets underway with minimum delay.

LARGE CAM-OPERATED PIERCING DIES

A Ford contribution to aircraft-manufacturing technique on bomber work at Willow Run Plant is the development of standardized cam-operated piercing punches for production of all holes in the flange of a part at one stroke of the press. Holes are pierced to 0.002 in. of template. As many as 781 individual punches have been built into one die to pierce a single row of holes in the flange of an elliptically shaped piece.

Cam-operated piercing punches are applied in several ways. In the most common application (Fig. 14), heat-treated driver *A* is attached to the punch-holder plate. Upon the down stroke, the driver contacts button-headed punch holder *B*, causing punch *C* to pierce the flange. A spring under the head of the punch retainer acts to strip the punch from the piece. Cemented to the inner end of the punch retainer is a rubber stripper to assist the spring action, especially when the material runs heavy in the gage or the punch becomes dull. The driver, punch retainer, spring, and punch are standardized. A contour cam that actuates a number of punches is used when a row of holes must be pierced around the periphery of a symmetrical part. Several punch retainers are held in sectional retainer blocks made to follow the work contour.

When rivet holes are too close together (less than 1-in. centers) for the use of this method, two fixed punches *A* (Fig. 15) are mounted in round slide *B*, which has a flat-bottomed heel *C*. The same type of fixed

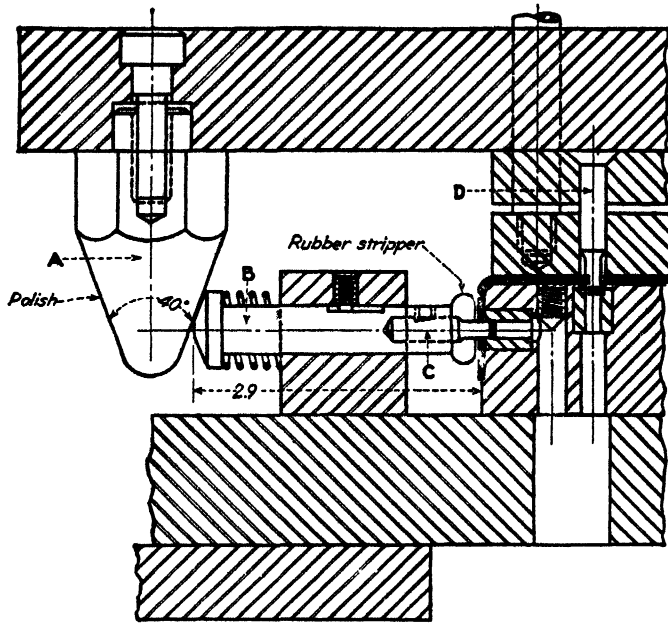


FIG. 14.—Button dies are used for piercing on contours. A rubber stripper assists the spring.

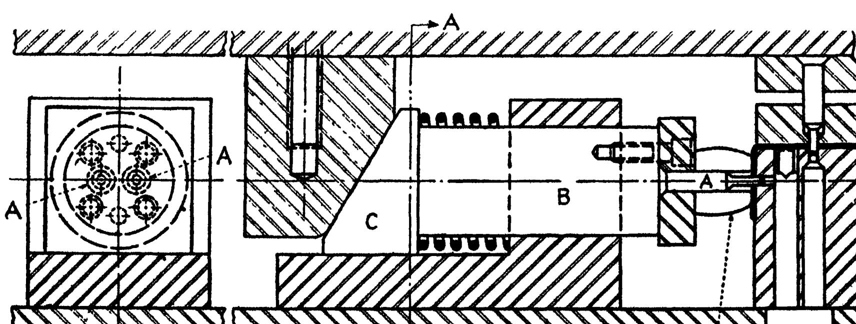


FIG. 15.—When rivet holes are closer than 1-in. centers, flat-head punches are mounted in a round punch slide with a flat-bottomed heel.

flat-head punch is used at *D* (Fig. 14) for piercing through the flat bottom of a flanged part.

Rivet holes must also be pierced one above another in the flange of some aircraft stampings. This problem is met by mounting two non-standard punch retainers, one above the other, in a single retainer block (Fig. 16). A two-step cam actuates both punches at the one stroke.

Standardization promotes the rapid building of piercing dies. The

punch holders and drivers seen in Fig. 14 are standard, being made up on bar machines. Plain and flat-head punches are standardized as to shank size and are produced on cold headers.

Scratches must be avoided in aluminum aircraft stampings, because these imperfections give rise to fatigue failure in highly stressed parts. As a consequence, punch and die surfaces must be glass-smooth.

Specifications call for chromium plating the punch and die surfaces in the forming and drawing tools which make up the bulk of the program.

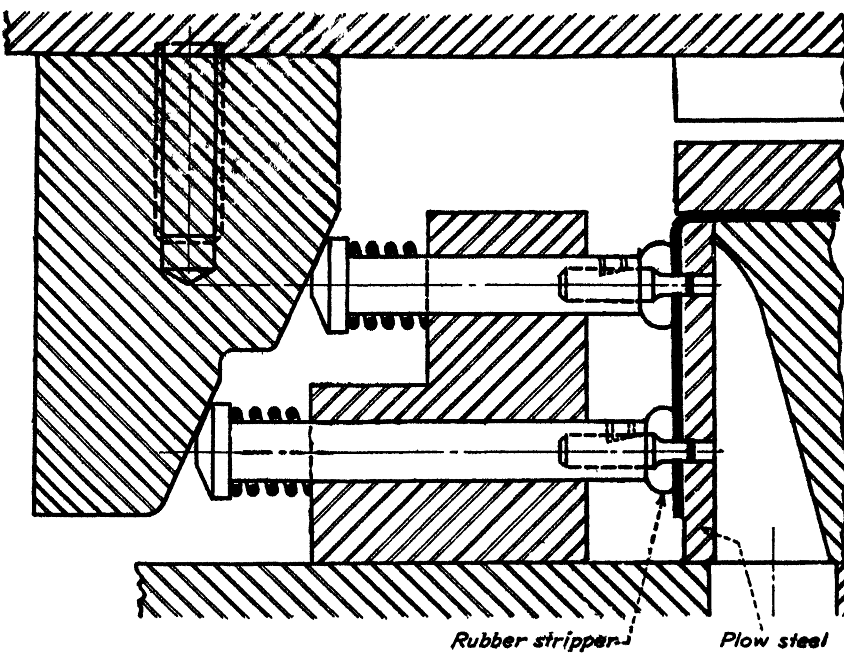


Fig. 16.—To pierce holes at various heights on the flange, non-standard punch retainers are operated in one stroke by a two-step cam.

But there are dies for which chromium plating is not applicable. Plating baths are not available for the huge cast-steel dies used for deep-drawing pilot-inclosure stampings. Long, thin die sections in some corrugating dies would presumably warp in a plating bath. Joints in chromium plated sectional dies would not be flush. For such cases, the polishing methods of the moldmaker are added to the conventional stoning used for automotive dies. Glass-smooth surfaces are produced without adding an excessive burden in percentage of total man-hours required to build the tools.

Die and punch surfaces are first hand-stoned by the common automotive method, using coarse- and fine-grit rubbing blocks. The polishing procedure is as follows:

First polishing: Cork and emery composition wheel and West alumina wheel.

Second polishing: Hand-stoning with fine-grit silicon-carbide stone and Sunoco oil.

Third polishing: Buckingham white-diamond stick and 3-in. felt wheel.

Other Big Presses and Tools

Reference has been made to the extent to which big hydraulic presses and other heavy equipment units have been applied to the production of

Fig 17 —Another heavy hydraulic press, drawing an aircraft tank section.

aircraft and other large metal stampings. The accompanying views show a number of large presses that are used for forming and drawing up such parts. For example, an HPM (Hydraulic Press Mfg Co.) Fastraverse self-contained press is shown in Fig. 17 engaged in drawing up an upper tank section for an airplane, the time required for drawing this from the flat blank being less than 1 min. This press is known as a "deep-drawing unit" and was adopted to take the place of a former method of production in which drop hammers were employed. The section is produced at one stroke of the press.

This self-contained press is equipped with hydraulic blank holder and die cushion. A matched punch and die set is used. A ring carried by the blank-holder slide holds the blank while the part is drawn. The

so-called "matched" die set is a pair of steel dies of conventional form instead of the rubber-pad type where a thick blanket or pad is utilized in place of the die usually secured to the upper movable platen of the press.

The same type of press as illustrated in Fig. 17, only of smaller size, can be used effectively for deep drawing of smaller sheet metal work. A main advantage of the blank-holder deep-drawing press is that the

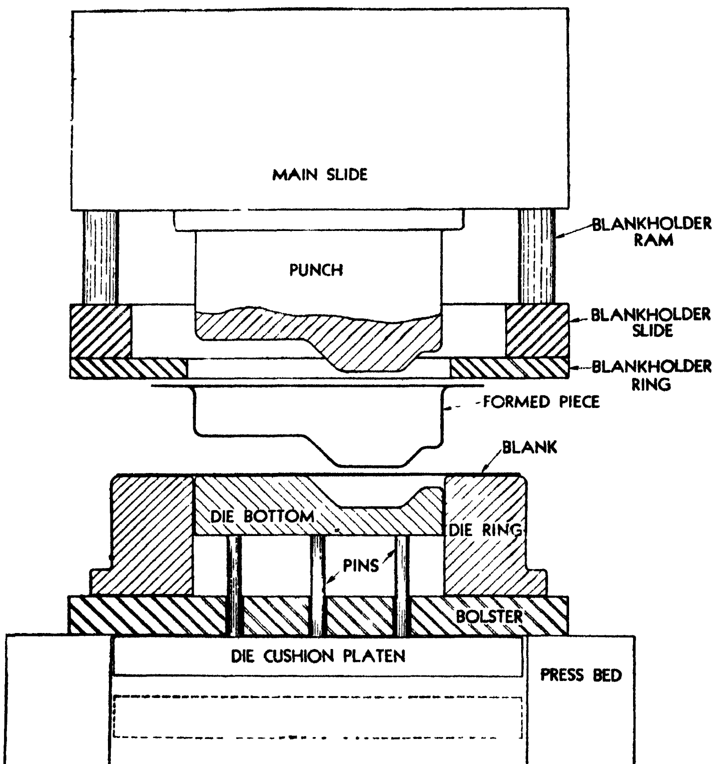


FIG. 18.—Deep-drawing press die set.

parts can be produced rapidly without wrinkling or tearing the sheet metal during the drawing operation.

Three different hydraulic ram movements are used, namely, main slide, blank-holder slide, and die-cushion platen.

A typical die set is shown in Fig. 18. The blank-holder slide is located below the main slide, and the blank-holder ring is mounted directly on the face of the blank-holder slide.

The holding pressure of the blank-holder ram is regulated so as to allow the metal to follow the contour of the draw punch travels through

the center opening of the blank-holder slide and on into the die ring. This permits the draw to be made without wrinkling or tearing the metal. As the drawing proceeds, the bottom of the piece is gripped between the punch and the die bottom, the latter being forced downward against a yielding resistance. In some cases the die cushion is used only as an ejector.

Big Work on Cowl Ventilators

Another line of very large work in the way of metal drawing is illustrated in Fig. 19, which represents a big cowl ventilator, one of a lot of

Fig. 19—Cowl ventilator stamped in halves and welded together. Press operation shown in Fig 20

over 20,000 produced for Liberty ships during the war. The ventilators were drawn up in halves and welded. The material was 14-gage cold rolled deep-drawing steel. The ventilator half is shown in Fig. 20, coming out of the press at the plant of the contractor, the Weber Showcase & Fixture Company, Los Angeles. The big hydraulic press was designed and built by this company and is said to be the largest drawing press yet constructed. The dies used for this big press work were made of Meehanite metal and for the largest sizes of cowls weighed about 13 tons. There were eight shapes of ventilators ranging from 20 to 72 in. in diameter and from 4 ft. 4½ in. in height to 8 ft. 6½ in. in height.

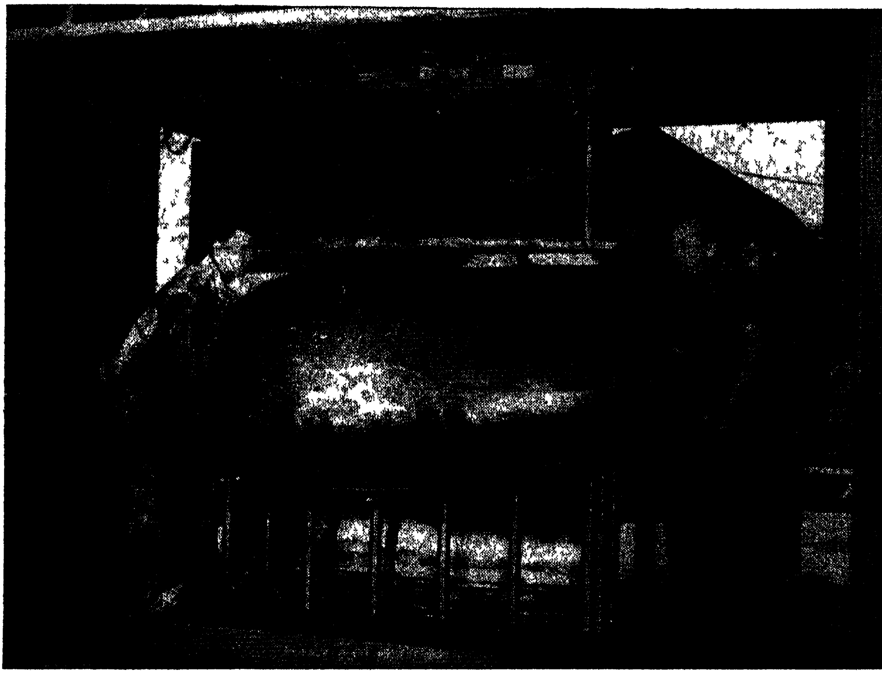


FIG. 20.—Largest drawing press shown drawing half sections for ships' cowl ventilators.

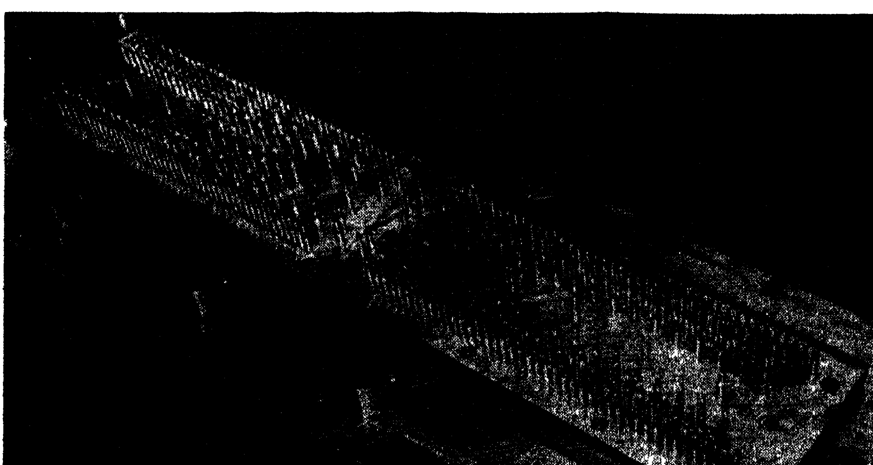


FIG. 21.—"Porcupine" punch for piercing 976 holes in Boeing Flying Fortress parts.

Large Piercing Die for Aircraft Work

The photographs, Figs. 21 and 22, represent a multiple-piercing die which was constructed by Boeing Aircraft Company and is believed to contain the greatest number of closely coordinated piercing punches ever built into an aircraft die. It was constructed with 388 punches with hole location accuracy of 0.0005 in. It was built to pierce a total of 976 riveting holes in 10 separate parts, which when assembled made up

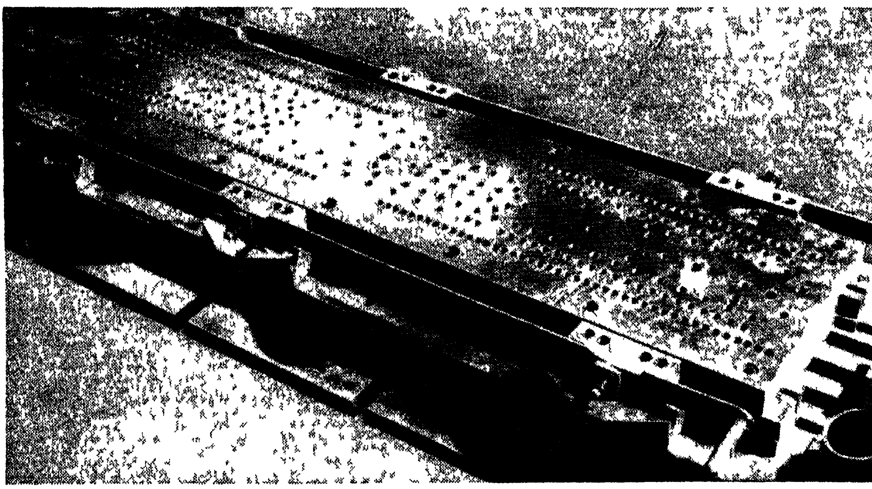


FIG 22.—One of the stripper plates used in "Porcupine" die for piercing five different sets of parts used in Flying Fortress construction

the walkway through the bomb bay of the Boeing Flying Fortress. On this Porcupine die set five different types of parts are pierced (two each in a set of ten) by means of a design by which stripper plates are easily changed to suit the part to be pierced. Aside from this stripper change the only change in the die during the five different press operations is in adjustment of stock pushers and indexing points for the material. To facilitate maintenance and grinding, the punches are mounted in two punch retainer plates. Also the guide pins are located on the punch head instead of the die to allow for precision grinding of the die plate without removing the guide pins.

Section VIII

TOOL STANDARDS, LAYOUT AND CONSTRUCTION METHODS

CHAPTER XX

PUNCH AND DIE STANDARDS

The illustrations and tables in this section cover various standards for punch and die parts, die shoes, punch holders, guide pins or pillars, etc. They are all representative of the practice of certain manufacturers who make extensive use of press tools of different classes and they should therefore be of direct service to many shops and to individual die makers and draftsmen employed where this class of material has not as yet been standardized.

Open Punch & Die Blocks

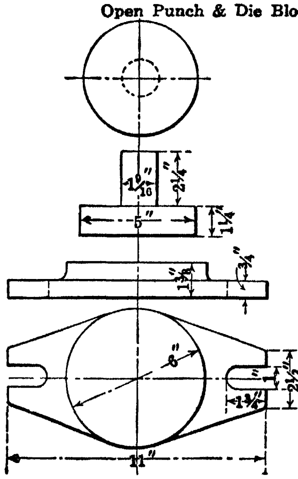


FIG. 1

Heavy Pattern Die Blocks

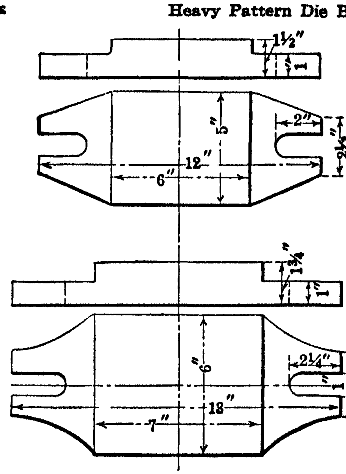


FIG. 2

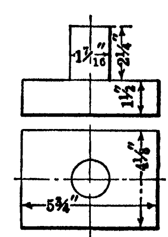


FIG. 3
Punch for Heavy Pattern Die Blocks

FIGS. 1–3.—Standard punch and die blocks.

The drawings and tables are largely self-explanatory, and only the briefest reference is necessary in the text.

The sketches, Figs. 1 to 3, show the standard plain open punch holders and die blocks used by one of the principal manufacturers of calculating machines. The majority of press tools in this shop are of the pillar type, and Figs. 4 to 7, inclusive, cover dimensions for the head and base as well as the guide pins or pillars.

The proportions of blanking dies proper, strippers, pressure pads, and nests for shaving dies are given in Figs. 8 to 11.

In Figs. 12 to 15 are shown the dimensions of punch holders and die shoes, also the scrap choppers, adopted by a prominent typewriter factory.

The tables and sketches reproduced in Figs. 16 to 24 show details developed from tools used in different shops manufacturing a variety of work, including automobile parts, small electric motors, mailing machine parts, etc. The punch and die holders in Fig. 16 are a development of the four-post type which were often found to cause difficulty through the front pins coming in the way of the operator. In most cases the dies equipped with two guide pins give as satisfactory results as where there

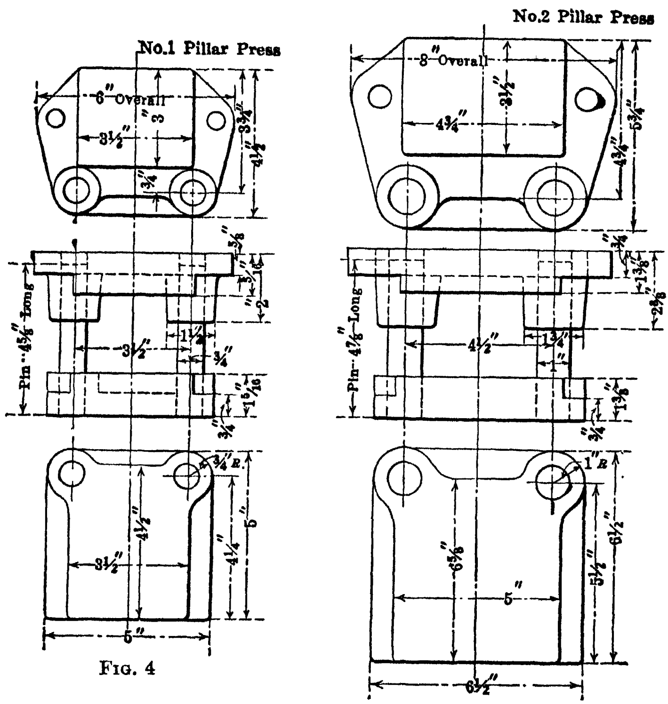


FIG. 4

FIG. 5

FIGS. 4–5.—Standard parts for pillar dies.

are four and the two-post type are considerably easier and more economical to make. The patterns for these holders are so made that they can be used in pairs and the two castings lined up for boring together. The usual practice is to face off both castings, clamp them together in the milling machine and bore both parts to a standard plug gage. Type A, Fig. 16, is used for general work and Type B, Fig. 17, is adapted especially for round work.

The guide pins in Fig. 18 are designed for use with blanking and piercing dies and are used in connection with the bushings in Fig. 19. It will be noticed that the pins and bushings are both ground for a press fit in

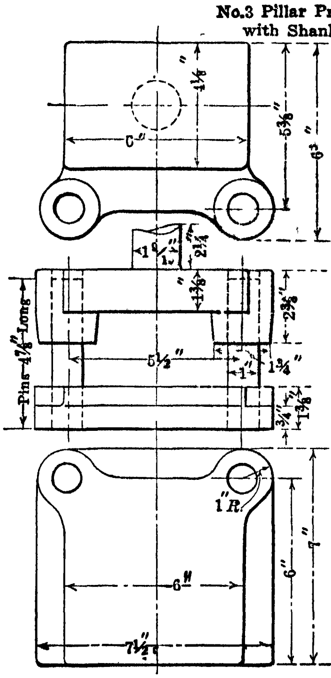


Fig. 6

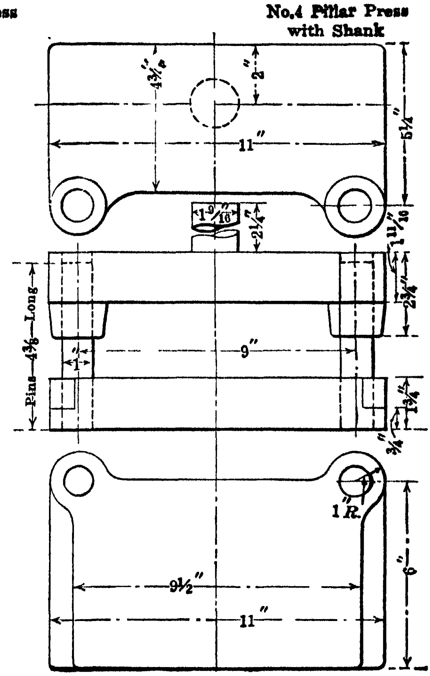


Fig. 7

Figs. 6-7.—Standard parts for pillar dies.

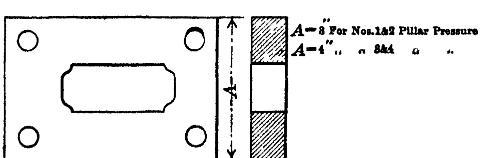


Fig. 8 Die

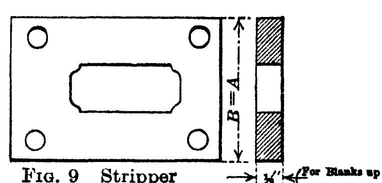


Fig. 9 Stripper

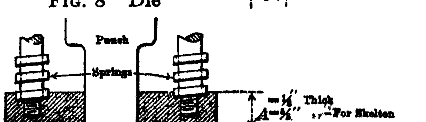


Fig. 10 Pressure Pad

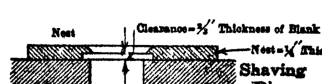


Fig. 11

Figs. 8-11.—Pressure pad and nest details.

STANDARD GUIDE POSTS — 7/8"-ST — 1"-ST — 13/16" ST — 13/16" ST

MAKE ONE GUIDE POST 1/16" LARGER THAN THE OTHER

FOR STANDARD GUIDE POSTS SEE INNER MARGIN

STANDARD PUNCH HOLDERS

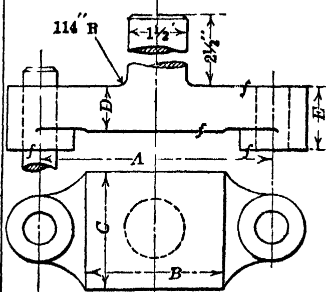


Fig. 12

A	B	C	D	E
6	3¾	3	1⅛	1¾
6	3¾	4	1⅛	1¾
7	4	3¼	1⅛	1¾
7	4	5	1⅛	1¾
8½	5	5	1⅛	1¾
8½	6	4	1⅛	1¾
9	7	4	1⅛	1¾
11	8	4½	1⅛	1¾
14	10	4½	1½	2
15	12½	3¾	1¾	2¾
16⅝	13	4¼	1¾	2¾

STANDARD DIE SHOES

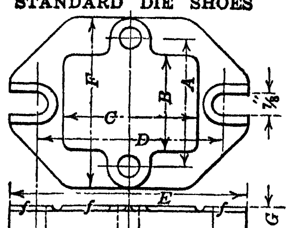


Fig. 13

A	B	C	D	E	F	G
6	4¾	5¾	8	10½	7⅝	1¼
9	7½	5¾	8	10½	10½	1½
7	6	7¾	9½	12	8⅝	1¼
6	5	6¾	9½	12	7⅝	1¼
8½	7	6¾	9½	12	10	1½
11	9½	6¾	9	11	13	1½

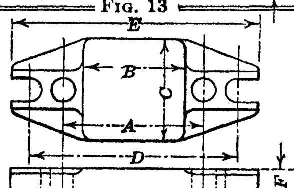


Fig. 14

A	B	C	D	E	F
6	4	4	8⅞	10⅛	1¼
7	5	4	9¾	12	1¼
7	5	5	9¾	12	1¼
9	7	4½	12¾	15	1¼
14	11	5½	17¾	20	2
15	13½	4¼	19	21	2¼
16⅝	15⅛	7	20	22½	1½

STANDARD SCRAP CHOPPER

W—Width of Stock

t—Thickness of Stock

Note:- The Die Shoe is Bolted to the Press Bed Thru. Two Holes. These Two Holes are the Distance A (See Charts above) From Center to Center.

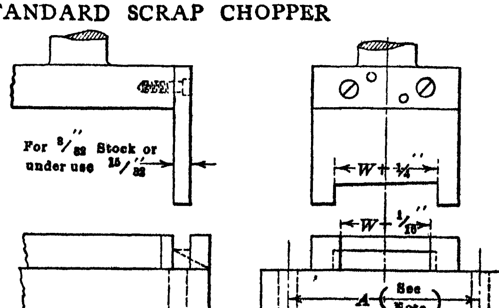
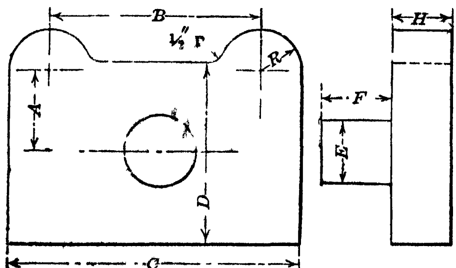


Fig. 15

Figs. 12–15.—Standard die shoes and punch holders.

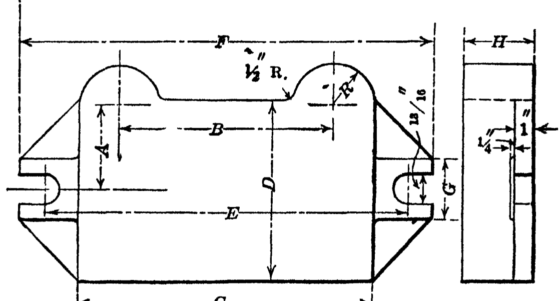
the same size of hole and that the small end of the pin is ground to a sliding fit in the bushing of the corresponding number.

The guide pins in Fig. 20 are intended to be used without bushings and are usually employed in forming dies or in cutting dies where the number of pieces to be produced will not warrant the making of bushings.



STANDARD PUNCH HOLDERS (TYPE *A*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*H*	*R*
1	3	5	8	6	2⅛	2½	2¾	1½
2	3½	6¾	10	7	2⅛	2½	2¾	1⅝
3	4	8¾	12	8	2⅛	2½	2¾	1⅝
4	4½	10½	14	9	2⅛	2½	3	1¾
5	5	12¼	16	10	2⅛	2½	3	1⅞



STANDARD DIE HOLDERS (TYPE *A*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*R*
1	3	5	8	6	10	12	2½	2¾	1½	1½
2	3½	6¾	10	7	12	14	2½	2¾	1½	1⅝
3	4	8¾	12	8	14	16	2½	2¾	1½	1⅝
4	4½	10½	14	9	16	18	2½	3	1½	1¾
5	5	12¼	16	10	18	20	2½	3	1½	1⅞

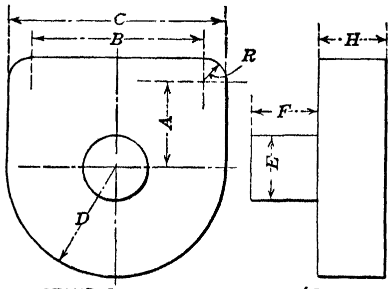
Fig. 16.—Punch and die standards.

Standardizing a Line of Typewriter Tools

The engravings that follow show the standards adopted by a typewriter manufacturer for use in a line of presses made up of Nos. 19, 20 and 73½ Bliss and Nos. 0 and 75-D Stiles machines. In Figs. 21 to 23 are illustrated the standards for the Stiles No. 0 press. The construction drawing, Fig. 21, shows the tools assembled and it will be noticed that

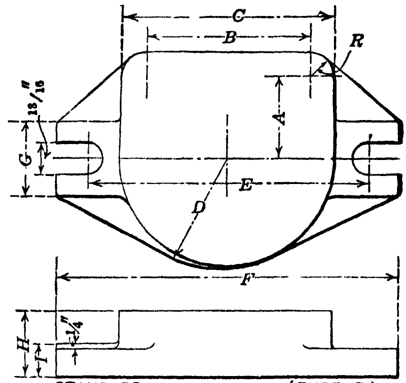
guide posts and bushings are used on all of these tools making each outfit practically a pillar sub press.

In Figs. 24 to 27 are shown the equipment for the No. 19 Bliss press. The shoe and punch holder for this press are made in six sizes. The punch



STANDARD PUNCH HOLDER (TYPE *B*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*H*	*R*
1	2½	5	8	4	2⅛	2½	2¾	1½
2	3⅜	6¾	10	5	2⅛	2½	2¾	1⅝
3	4⅜	8¾	12	6	2⅛	2½	2¾	1⅝
4	5¼	10½	14	7	2⅛	2½	3	1¾
5	6⅛	12¼	16	8	2⅛	2½	3	1⅞



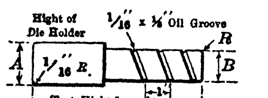
STANDARD DIE HOLDERS (TYPE *B*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*R*
1	2½	5	8	4	10	12	2½	2¾	1½	1½
2	3⅜	6¾	10	5	12	14	2½	2¾	1½	1⅝
3	4⅜	8¾	12	6	14	16	2½	2¾	1½	1⅝
4	5¼	10½	14	7	16	18	2¾	3	1½	1¾
5	6⅛	12¼	16	8	18	20	2¾	3	1½	1⅞

FIG. 17.—Punch and die standards.

holders are shown in Fig. 31 and are the same as those used on the No. 20 press. In Fig. 27 is shown the planning for all the gates for No. 19 presses and also the key for holding the punch holders in the gate.

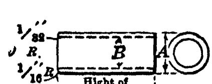
The standards for the No. 20 press are given in Figs. 28 to 35. There are two combinations of standards for this size of press—one in which



Tool Steel Guide Pins Hdn. & Grind

No	*A*	*B*	*R*	Radius of Base
1	1.002	0.999	¼	1⅛
2	1.127	1.124	¼	1⅛
3	1.252	1.249	¼	1⅛
4	1.377	1.378	¼	1⅛
5	1.502	1.498	⅜	1⅛

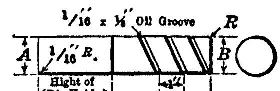
FIG. 18



Guide Pins-Bushings Tool Steel Hdn. & Grind

No	*A*	*B*	Radius of Base
1	1.376	1.000	1⅛
2	1.501	1.125	1⅛
3	1.626	1.250	1⅛
4	1.751	1.375	1⅛
5	1.876	1.500	1⅛

FIG. 19



Guide Pins-Tool Steel Hdn. & Grind

No	*A*	*B*	*R*	Radius of Base
1	1.002	0.999	¼	1⅛
2	1.127	1.124	¼	1⅛
3	1.252	1.249	¼	1⅛
4	1.877	1.373	¼	1⅛
5	1.502	1.498	⅜	1⅛

FIG. 20

FIGS. 18–20.—Standard guide pins and bushings.

the guides are on the center line of the press sidewise, and the other where the guides are placed one in front and the other in the rear of the center line of the press.

As Nos. 19 and 20 presses are most in use here, standard die blanks are carried in stock rough planed, and they are finished planed as required to suit specific conditions. In many cases rectangular blanks are employed,

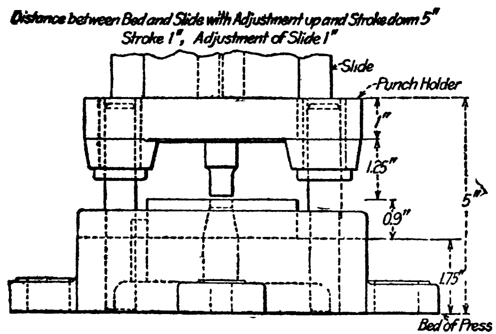


FIG. 21

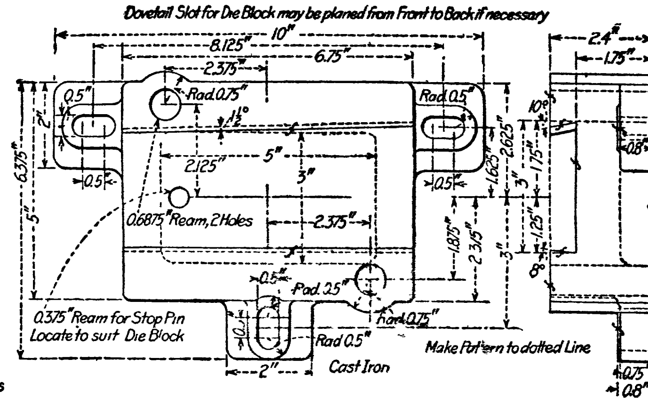


FIG. 22

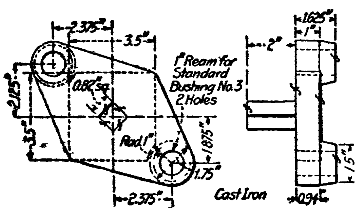


FIG. 23

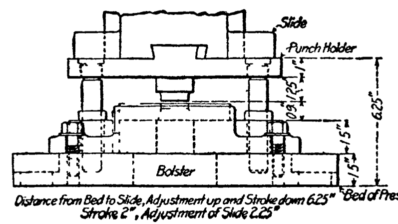
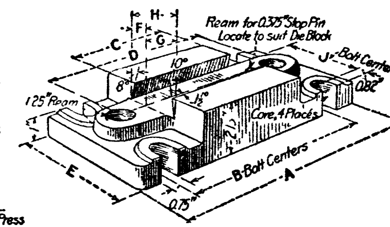


FIG. 24



No.	A	B	C	D	E	F	G	H	J
40	11.5"	8.5"	4"	6.5"	6"	1.25"	1.75"	3"	4.75"
41	11.5"	8.5"	5"	7.5"	6"	1.25"	1.75"	3"	4.75"
42	11.5"	8.5"	6"	8.5"	6"	1.25"	1.75"	3"	4.75"
43	12.5"	9.75"	4.5"	7"	7"	1.75"	2.25"	4"	5.75"
44	12.5"	9.75"	5.5"	8"	7"	1.75"	2.25"	4"	5.75"
45	12.5"	9.75"	6.5"	9"	7"	1.75"	2.25"	4"	5.75"

FIG. 25

FIGS. 21–25.—Standard dimensions of various press parts.

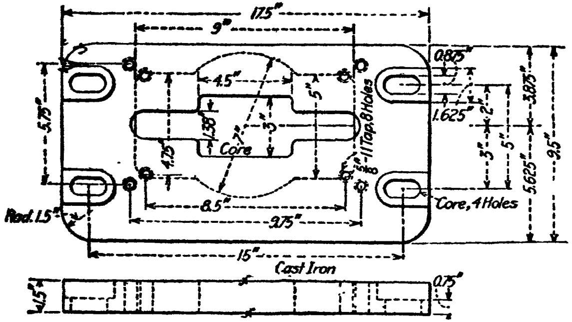


Fig. 26.—Bolster and bed opening

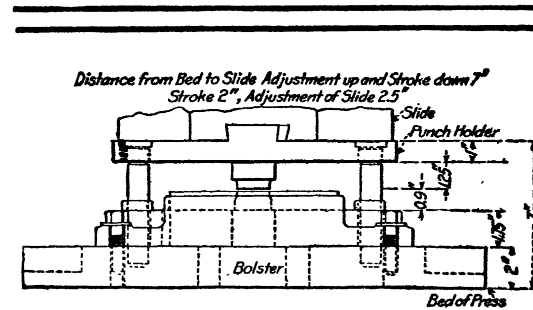


Fig. 28.—Tools for No. 20 Bliss Press

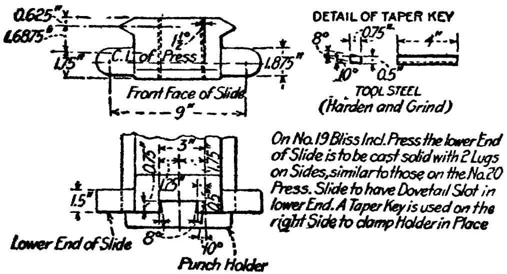


Fig. 27

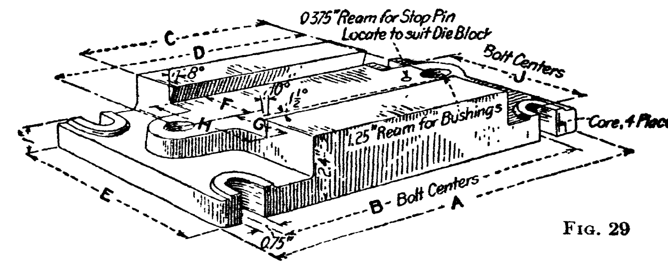
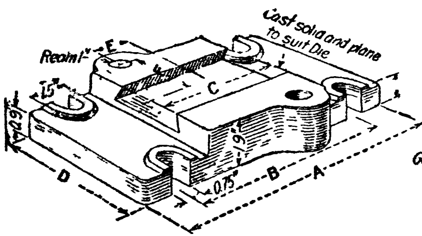


Fig. 29

No.	A	B	C	D	E	F	G	H	J
1	11.5"	8.5"	4"	6.5"	6"	1.25"	1.75"	3"	4.75"
2	11.5"	8.5"	5"	7.5"	6"	1.25"	1.75"	3"	4.75"
3	11.5"	8.5"	6"	8.5"	6"	1.25"	1.75"	3"	4.75"
4	12.5"	9.75"	4.5"	7"	7"	1.75"	1.25"	4"	5.75"
5	12.5"	9.75"	5.5"	8"	7"	1.75"	2.25"	4"	5.75"
6	12.5"	9.75"	6.5"	9"	7"	1.75"	2.25"	4"	5.75"
7	14.5"	11.5"	6"	8.5"	8"	2.25"	2.75"	5"	6.75"
8	14.5"	11.5"	7"	9.5"	8"	2.25"	2.75"	5"	6.75"
9	14.5	11.5"	8.5"	11"	8"	2.25"	2.75"	5"	6.75"

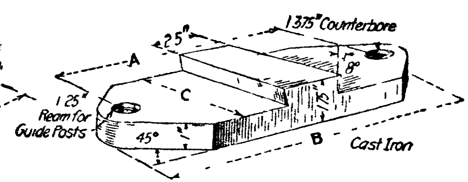
Figs. 26–29.—Standard punch holders and shoes.



No.	A	B	C	D	E	F
50	11.5"	8.5"	6"	6"	1.5"	2.875"
51	12.5"	9.75"	7"	7"	2.125"	2.875"

STANDARD SHOES FOR No. 20 BLISS INCL PRESS

FIG. 30

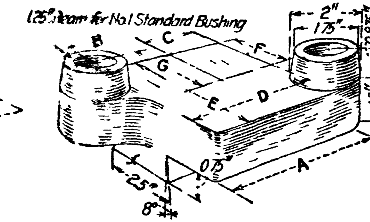


No	A	B	C
1	6.5"	9"	3.5"
2	7.5"	10"	3.5"
3	8.5"	11"	3.5"
4	7"	9.5"	4.5"
5	8"	10.5"	4.5"

No	A	B	C
6	9"	11.5"	4.5"
7	8.5"	11"	5.5"
8	9.5"	12"	5.5"
9	11"	13.5"	5.5"

Nos 1 to 6 inclusive are also used on the No 19 Bliss incl Press

FIG 31.



No	A	B	C	D	E	F	G
50	5.125"	2.875"	2.25"	4.5"	5"	2.5"	1.5"
51	5.125"	2.875"	2.25"	4.5"	6.25"	3.125"	2.125"

FIG. 32

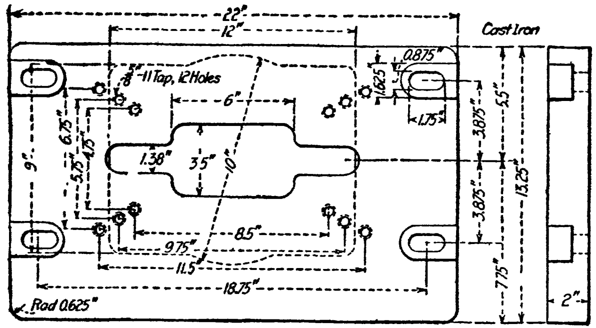


FIG. 34

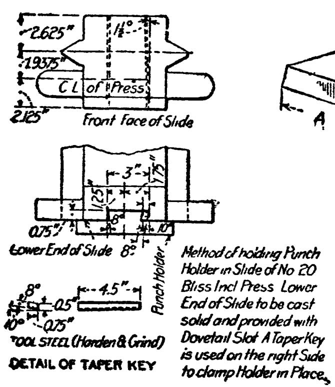
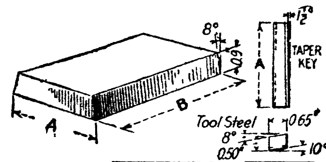


FIG. 35



No	A	B
1	2.5"	3.5"
2	2.5"	4.5"
3	2.5"	5.5"
4	3.5"	4"
5	3.5"	5"
6	3.5"	6"
7	4.5"	5.5"
8	4.5"	6.5"
9	4.5"	8"

No.	A
1	4"
2	5"
3	6"
4	4.5"
5	5.5"
6	6.5"
7	6"
8	7"
9	8.5"

FIG. 33

FIGS. 33–35.—Standards for No. 20 press.

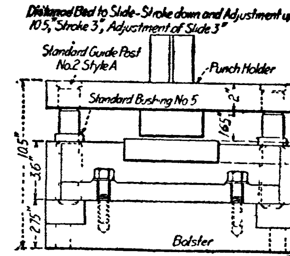


FIG. 36

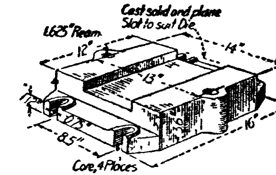


FIG. 37a

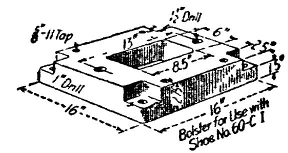


FIG. 37b

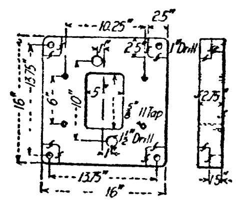


FIG. 38

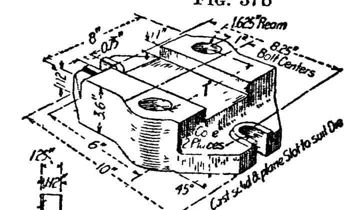
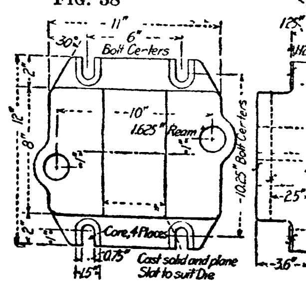


FIG. 39a



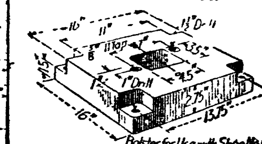


FIG. 39b

FIGS. 36–39.—Standards for No. $79\frac{1}{2}$ press.

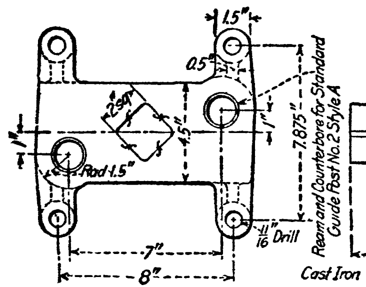


Fig. 40

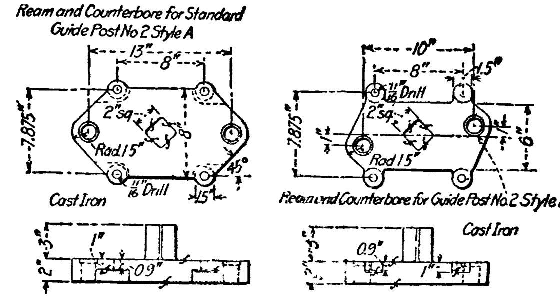


Fig. 41

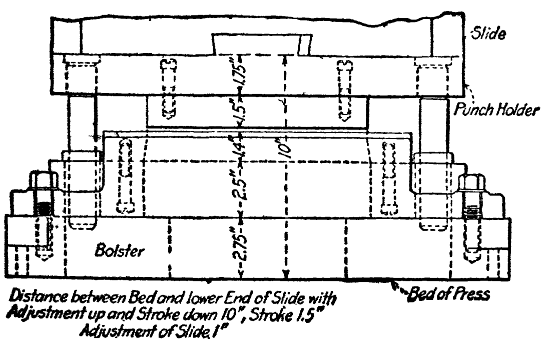
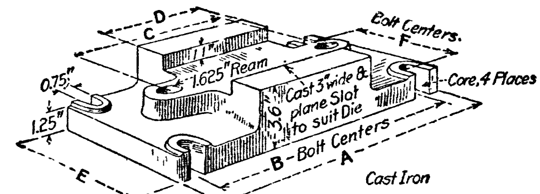


Fig. 42

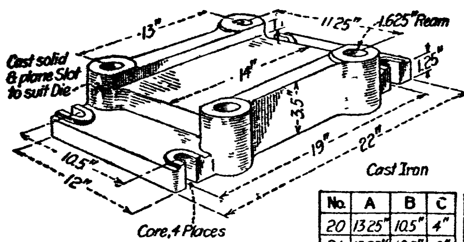


No	A	B	C	D	E	F
20	16"	13"	10.5"	8"	7"	5.75"
21	16"	13"	10.5"	8"	9"	7.75"
22	16"	13"	12"	10"	7"	5.75"
23	16"	13"	12"	10"	9"	7.75"
24	16"	13"	12"	10"	12"	10.75"
25	20"	17"	14"	12"	7"	5.75"
26	20"	17"	14"	12"	9"	7.75"
27	20"	17"	14"	12"	12"	10.75"
28	20"	17"	16"	14"	7"	5.75"
29	20"	17"	16"	14"	9"	7.75"
30	20"	17"	16"	14"	12"	10.75"

Fig. 43

Figs. 40–43.—Punch holder, tools, and shoes for various presses.

FIG. 44.



STANDARD SHOE FOR No. 75 D STILES DOUBLE PITMAN PRESS FOR USE WITH 4 GUIDE POSTS

No.	A	B	C
20	13.25"	10.5"	4"
21	13.25"	10.5"	6"
22	14.75"	12"	4"
23	14.75"	12"	6"
24	14.75"	12"	8"

No.	A	B	C
25	16.75"	14"	4"
26	16.75"	14"	6"
27	16.75"	14"	8"
28	18.75"	16"	4"
29	18.75"	16"	6"
30	18.75"	16"	8"

FIG. 45.

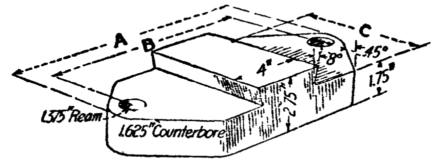
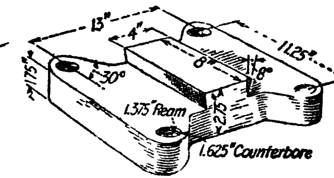


FIG. 46



STANDARD PUNCH HOLDERS FOR No. 75 D STILES DOUBLE PITMAN PRESS

This Style of Bolster is used with Dies having Two Guide Posts. Cast Iron

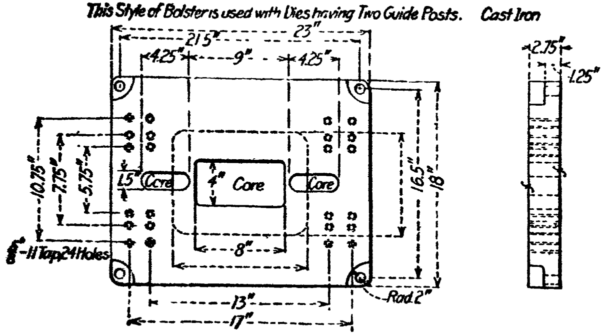
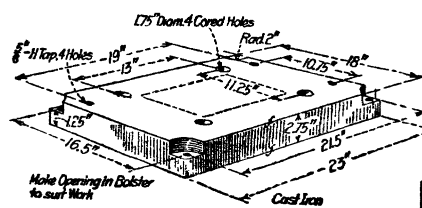
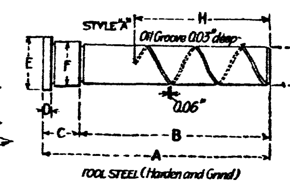


FIG. 47.—Bolster and opening in bed for No. 75-D press.





No.	A	B	C	D	E	F	G	H
1	6"	5"	1"	0.25"	1.375"	1.126"	0.9995"	3.5"
2	7.75"	6"	1.75"	0.38"	1.625"	1.376"	1.2435"	4"

FIG. 48.—Special bolster and standard guide.

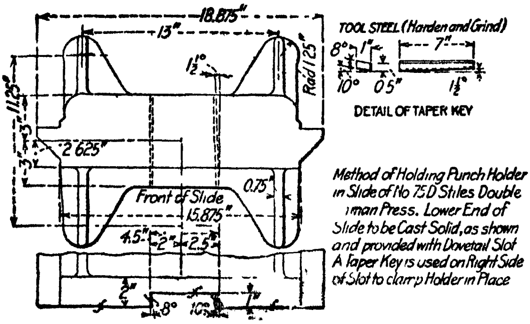
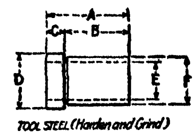


FIG. 49.– Punch holder for No 75-D press



No.	A	B	C	D	E	F
1	2.25"	1.75"	0.5"	1.44"	1"	1.251"
2	3"	2.5"	0.5"	1.75"	1.25"	1.626"
3	1.87"	1.62"	0.25"	1.25"	0.75"	1.001"
4	2"	1.5"	0.5"	1.44"	1"	1.251"
5	4.1"	3.6"	0.5"	1.75"	1.25"	1.626"

FIG 50 —Special bolster and standard guide

No.	A	B	C	D	E
1	4.75"	2.25"	2.50"	0.6885"	0.7495"

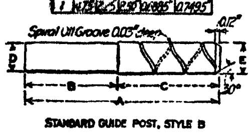


FIG 51

No.	A	B	C	D	E
1	4.60"	1.90"	2.70"	1.001"	0.999"

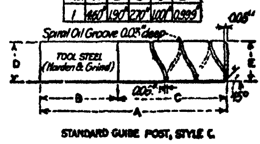
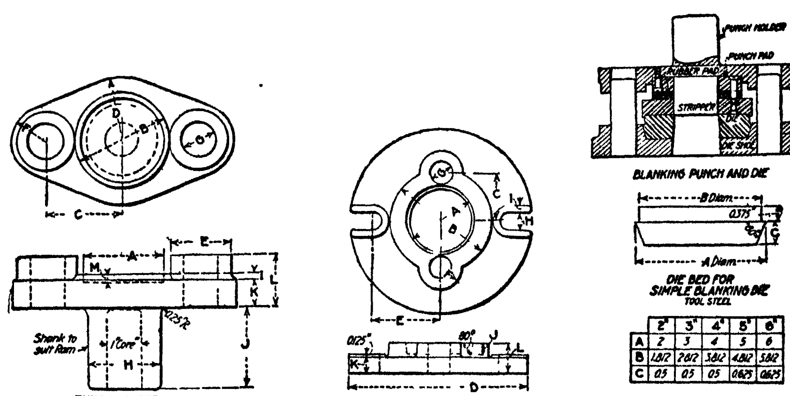


FIG 52

FIGS 51–52.—Standard guide posts



PUNCH HOLDER FOR SIMPLE BLANKING DIES, STEEL CASTING

	2"	3"	4"	5"	6"
A	1.75	2.25	3.25	4	5
B	2.125	2.75	4	5	6
C	1.75	2.125	2.75	3.312	3.812
D	1.25	1.75	2	2.5	3
E	1.25	1.75	1.75	2	2.25
F	0.75	1	1	1.125	1.25
G	0.75	1	1	1.125	1.125
H	1.5	2	2	2	2
I	0.125	0.125	0.125	0.125	0.25
J	1.75	2.25	2.25	2.25	2.25
K	0.625	0.75	0.875	1	1.125
L	1.125	1.375	1.6	1.5	1.75
M	0.125	0.125	0.125	0.25	0.25

DIE SHOE FOR SIMPLE BLANKING DIE, STEEL CASTING

	2"	3"	4"	5"	6"
A	2	3	4	5	6
B	3	4.5	5.25	6.5	7.75
C	1.75	2.125	2.75	3.312	3.812
D	4.5	8.25	8.25	9.5	11.25
E		3.125	3.375	4	4.75
F	0.875	1	1	1.125	1.125
G	0.75	1	1	1.125	1.125
H		0.812	0.812	0.812	0.812
I		0.312	0.312	0.312	0.312
J	0.5	0.5	0.5	0.625	0.625
K	0.625	0.75	0.875	0.875	1
L	1.25	1.375	1.375	1.375	1.875

DIE BED FOR SIMPLE BLANKING DIE, TOOL STEEL

	2"	3"	4"	5"	6"
A	2	3	4	5	6
B	1.812	2.812	3.812	4.812	5.812
C	0.5	0.5	0.5	0.625	0.625

STRIPPER FOR SIMPLE BLANKING DIE, MILD STEEL

	2"	3"	4"	5"	6"
A	1.812	2.812	3.812	4.812	5.812
B	2	3	4	5	6
C	0.625	0.625	0.75	0.75	0.875
D	0.093	0.093	0.093	0.093	0.093

PUNCH PAD FOR SIMPLE BLANKING DIE

	2"	3"	4"	5"	6"
A	1.75	2.75	3.25	4	5
B	0.5	0.5	0.625	0.625	0.75

FIG. 53.—Simple blanking punch holder, die shoe, and details.

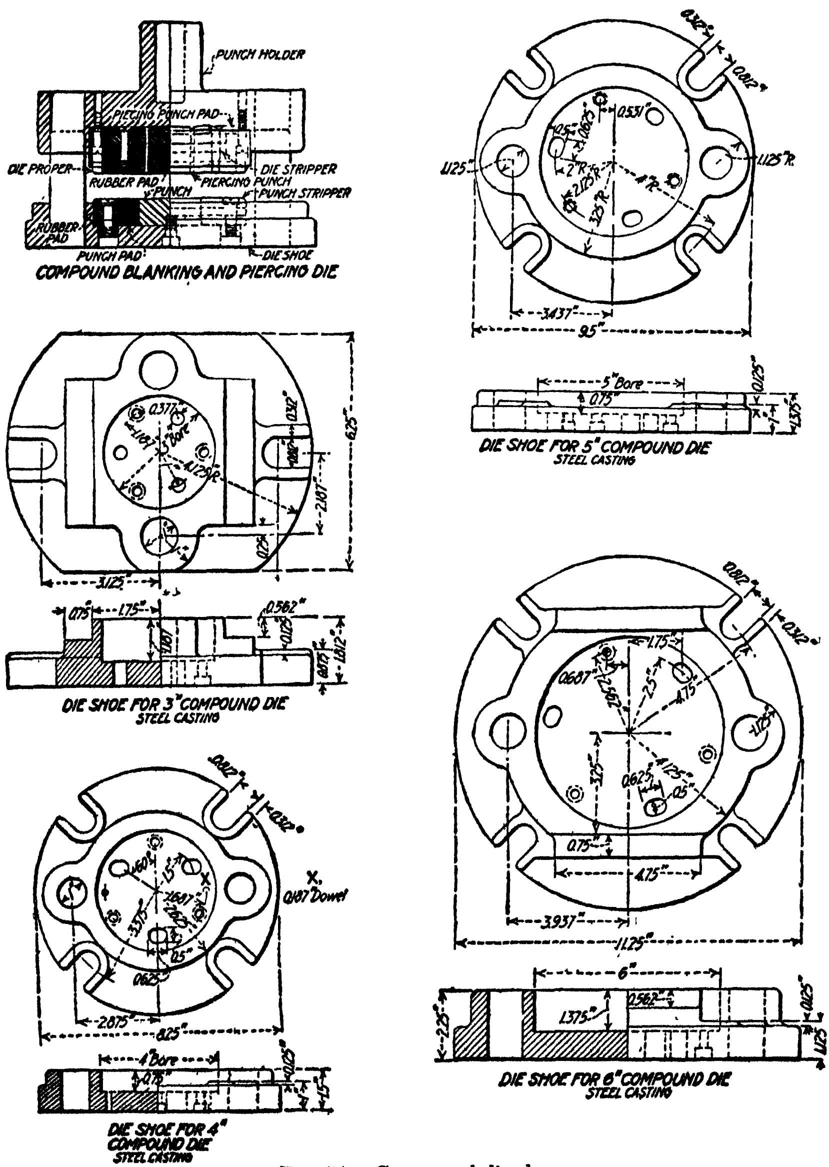
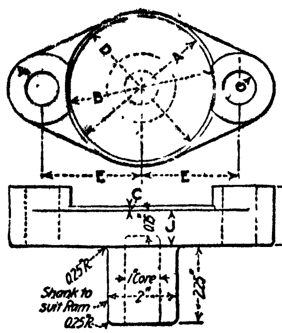


FIG. 54.—Compound die shoes.

these being screwed into place without the aid of keys. The bolster plate and the standard opening in the bed of the press are shown in Fig. 34.

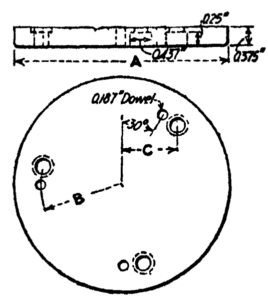
In Figs. 36 to 41 are illustrated the standard holders for the No. 79½ press. These holders are made in three different styles of one size each to suit varied conditions. In Figs. 42 to 49 are represented the standard punch and die holders for the No. 75-D Stiles double pitman press. These require no description.

The standard guide posts and guide bushings are illustrated in Fig. 50 and two other forms of guide posts are shown in Figs. 51 and 52.



PUNCH HOLDER FOR COMPOUND DIES
STEEL CASTING

	3"	4"	5"	6"
A	3.25	4.25	5.25	6.25
B	3.375	4.5	5.5	6.5
C	0.125	0.125	0.125	0.25
D	3.625	4.5	5.5	6.75
E	2.187	2.875	3.437	3.937
F	1	1	1.125	1.125
G	1	1	1.125	1.125
H	1.5	1.75	2	2.375
J	0.875	1	1.125	1



PUNCH STRIPPER FOR COMPOUND DIE
MILD STEEL

	3"	4"	5"	6"
A	3	4	5	6
B	1	1.5	2	2.5
C	0.812	1.062	1.375	1.75

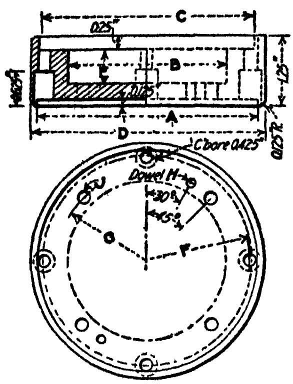
FIG. 55.—Punch holder and stripper for compound die.

SIMPLE AND COMPOUND DIE STANDARDS

The tools, shown in Figs. 53 to 57, were developed in a factory engaged on small press work. The drawings are given in detail and are self-explanatory. The dies in Fig. 53 are of the simple open type; those in the other drawings are of compound tools. All parts are kept in stock and are drilled together for screws and dowels. The shanks and bolt lugs are of course made to suit the press.

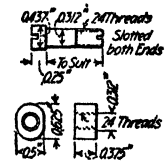
LOCATIONS OF HOLES IN BOLSTERS

It is often noticed in press rooms that bolsters are drilled indiscriminately for screw holes which are located more or less carelessly to suit different dies. To overcome this and other disadvantages the system

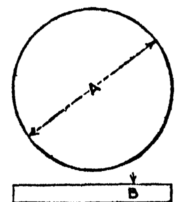


DIE HOLDER FOR COMPOUND DIE
MILD STEEL

	3"	4"	5"	6"
A	3	4	5	6
B	2.25	2.875	3.75	4.75
C	2.875	3.875	4.625	5.625
D	3.25	4.25	5.25	6.25
E	0.687	0.625	0.562	0.562
F	1.437	1.875	2.375	2.875
G	1.25	1.625	2.125	2.625
H	0.125	0.125	0.187	0.187
J	1.B.A.	1.B.A.	0.B.A.	0.B.A.



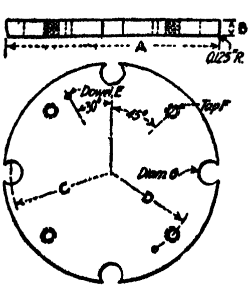
STRIPPER SCREWS FOR COMPOUND DIES



DIE STRIPPER FOR COMPOUND DIES
CAST STEEL, TOUGHENED

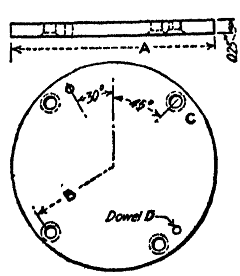
	3"	4"	5"	6"
A	2.25	2.875	3.75	4.75
B	0.312	0.312	0.312	0.375

FIG. 56.—Details of compound die.



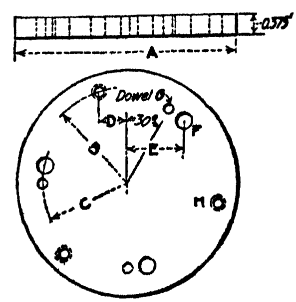
DIE FOR COMPOUND DIES
TOOL STEEL, HARDENED AND GROUND

	3"	4"	5"	6"
A	3	4	5	6
B	0.25	0.312	0.375	0.437
C	1.437	1.875	2.375	2.875
D	1.25	1.625	2.125	2.625
E	0.125	0.125	0.187	0.187
F	1.B.A.	1.B.A.	0.B.A.	0.B.A.
G	0.375	0.625	0.625	0.625



PIERCING PUNCH PAD FOR COMPOUND DIES
MILD STEEL

	3"	4"	5"	6"
A	2.875	3.875	4.625	5.625
B	1.25	1.75	2.125	2.625
C	1.B.A.	0.B.A.	0.B.A.	0.B.A.
D	0.125	0.187	0.187	0.187



PUNCH PAD FOR COMPOUND DIES
MILD STEEL

	3"	4"	5"	6"
A	3	4	5	6
B	1.187	1.687	2.125	2.562
C	1	1.5	2	2.5
D	0.593	0.842	0.531	0.687
E	0.812	1.062	1.375	1.75
F	0.375	0.312	0.312	0.312
G	0.187	0.187	0.187	0.187
H	0.25	0.25	0.312	0.312

FIG. 57.—Compound die details.

represented in Fig. 58 has been developed wherein only eight holes are drilled and tapped into the bolster plate.

The tapping is done through the bolster so that no dirt or punchings can lodge at the bottom, but must fall through, thus keeping the holes clear at all times. The die shoe is made of cast iron and has ears at both ends with open elongated slots that have ample clearance, so the bolts enter readily. This also permits adjustment of the die after the shoe containing the die has been placed upon the bolster plate. The holes are so positioned that the shoe may be placed either from front to back or from right to left on the press.

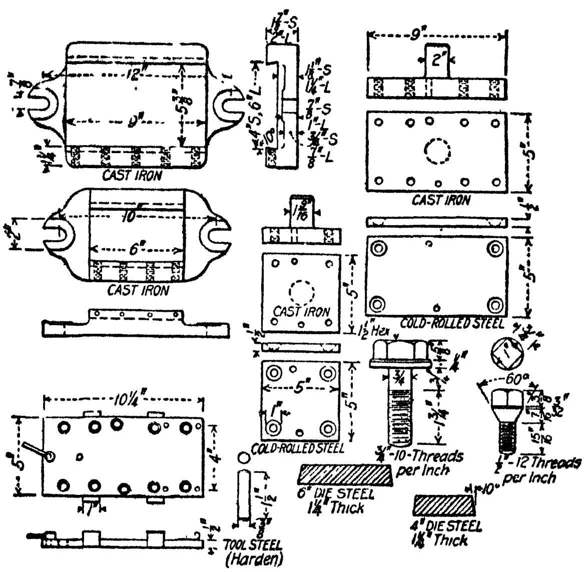


FIG. 58.—Die shoe, punch holder, and drill jig.

Only two sizes of shoes are in use where this system has been developed. These accommodate 4- and 6-in. width die steel that has been planed in 10-ft. lengths with a 10-deg. bevel on each edge and from which pieces are sawed off to the lengths required. These die-steel pieces are held in the die shoe by dog-point tool-steel setscrews that pass through the sides of the die shoe at the same angle as the side edges of the die—10 degrees. The 4-in. shoe is fastened to the bolster by two $\frac{3}{4}$-in. special-head screws in holes that are tapped 10 in. apart in the bolster, and the 6-in. shoe by screws tapped into holes 12 in. apart.

The punches are mounted in $\frac{1}{2}$-in. thick by 5-in. wide cold rolled steel plates made in two lengths—5 in. and 9 in. These cold rolled steel punch plates are fastened to cast iron punch holders of the same length by four special taper-headed casehardened screws, as shown in the drawing.

Two dowel pins assist these screws to prevent any shifting of the punch plate.

By mounting punches in the cold rolled steel prior to fastening to the cast iron punch holder it is evident that not only is it possible to do more accurate work, but also the shank of the holder cannot interfere in the positioning process, as in the old-style methods. With this system only two punch holders are required for each press instead of one for each die in use. The die shoes and punch plates are interchangeable on all presses. A drill jig must be provided, as in the drawing, and it will be observed that there are removable pins and an eccentric clamp with which both sizes of punch plates and punch holder are drilled. The hardened-steel dowel pins shown are a driving fit into the punch holders and remain in them at all times.

It has been learned that this method saves over 20 per cent of the cost of making the punches and dies, and after that the saving in the press room is beyond estimate.

CHAPTER XXI

FINDING THE SIZE OF BLANKS FOR SHELLS AND OTHER DRAWN WORK

In laying out blanking dies for shells and other work the die maker has occasion now and then to do a little figuring to find the area of different forms and to determine the outside dimensions of given areas of circles, ellipses, squares, rectangles, and other shapes. Certain tables

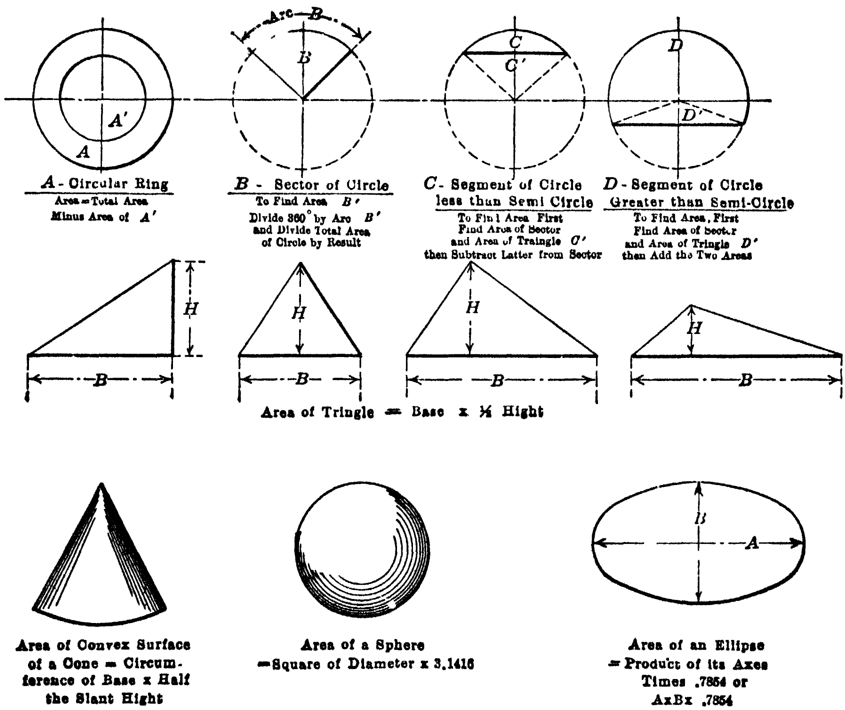
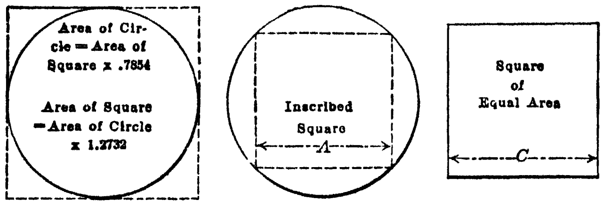


Fig. 59.—Plane surfaces, and cones and spheres.

included in this chapter will be of assistance in the finding of shell blank diameters. Before taking these up for consideration a few facts relative to the computing of areas and dimensions of circles and other regular figures will be referred to.

Table 1, page 494, lists simple rules for finding the various dimensions and the areas of circles and for determining the relations between circles and squares either inscribed or circumscribed. Figure 59 includes

TABLE 1.—RULES FOR FINDING DIMENSIONS OF CIRCLES AND SQUARES



To find	Having given	Rule
Circumference	Diameter	Multiply diam. by 3.1416 or divide diam. by 0.3183.
Circumference	Area	Divide area by 0.07958 and find square root of quotient.
Circumference	Side of an inscribed square (A)	Multiply side (A) by 4.443.
Circumference	Side of square of equal area (C)	Multiply side (C) by 3.545.
Diameter	Circumference	Multiply circumference by 0.3183 or divide circumference by 3.1416.
Diameter	Area	Divide area by 0.7854 and find square root of quotient.
Diameter	Side of an inscribed square (A)	Divide side (A) by 0.7071 or multiply side (A) by 1.4142.
Diameter	Side of square of equal area (C)	Multiply side (C) by 1.1284 or divide side (C) by 0.8862.
Radius	Circumference	Multiply circumference by 0.15915 or divide circumference by 6.28318.
Area	Circumference	Multiply the square of the circumference by 0.07958.
Area	Diameter	Multiply the square of the diameter by 0.7854.
Area	Radius	Multiply the square of the radius by 3.1416.
Area	Circumference and diameter	Multiply the circumference by one-quarter the diameter.
Side of an inscribed square (A)	Diameter	Multiply diameter by 0.7071.
Side of an inscribed square (A)	Circumference	Multiply circumference by 0.2251 or divide circumference by 4.4428.
Side of a square of equal area (C)	Diameter	Multiply diameter by 0.8862 or divide diameter by 1.1284.
Side of a square of equal area (C)	Circumference	Multiply circumference by 0.2821 or divide circumference by 3.545.

in diagrammatic form, various plane figures, the areas of which the die maker has to compute occasionally, and also covers simple rules for finding the surface areas of cones and spheres. The ellipse, the triangles, and the cone and sphere have often to be worked out for surface areas for work which is to be formed or drawn and it will be found convenient to have the simple rules available for making the necessary calculations. The rules in Table 1 and Fig. 59 are self-explanatory. In the table they are so arranged that with any part given, the required part or dimension can be found at once by following the rule in the third column.

Tables for Shell Blank Diameters

Table 2 has been computed by the E. W. Bliss Company for approximate diameters of blanks for shells from $\frac{1}{4}$ in. diameter by $\frac{1}{2}$ in. high, to 12 in. diameter by 12 in. high. These pages of tables should be found of service for blank calculations. It will be seen from the footnote that shells in the table are figured with sharp corners at the bottom and diameters of shells are taken from the center walls. These blank sizes are approximate only but they will be found a guide for the purpose intended. Necessarily they do not include any allowance for stretch of metal and they are figured without reference to the thickness of the material. The formula used in the computations is given in the footnote and will be found useful in making calculations for other sizes of work not within the range of the tables.

In making different calculations for blanks of various dimensions, complete tables of circles with areas, and circumference are extremely useful, and indispensable data of this kind with other tables on stock thicknesses by gages, weights, etc., will be found in the *American Machinist's Handbook* worked out to the smallest detail for convenience of reference. It is taken for granted that the above book is already in the hands of the reader of this volume and it is therefore unnecessary to reproduce in this treatise the tables referred to which with other valuable reference matter pertaining to the subject run to many pages in extent. A table of stock thicknesses by the most commonly used gages is, however, given in this book on page 56, Chapter II.

Laying Out a Blank for a Rectangular Drawn Shell

To eliminate some of the trial blanks in making dies for drawing rectangular boxes the following method is suggested:

Let us assume that the box at C, Fig. 60, is required and we wish to determine the size and shape of the blank. We draw the center lines B, Fig. 61, after which the bottom of the box is laid out as at C; then lay out the outer box D, the distance from C to D being slightly less than the

TABLE 2.—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS. (E. W. BLISS CO.)
From $\frac{1}{4}$ In. Diameter by $\frac{1}{2}$ In. High to $2\frac{7}{8}$ In. Diameter by $3\frac{3}{4}$ In. High

Diameter of shell	Height of shell																				Diameter of shell
	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	
$\frac{1}{4}$	0.75	0.83	0.90	0.97	1.03	1.09	1.15	1.20	1.25	1.30	1.34	1.39	1.43	1.52	1.59	1.67	1.75	1.82	1.89	1.95	$\frac{1}{4}$
$\frac{3}{8}$	0.94	1.04	1.13	1.21	1.28	1.34	1.42	1.48	1.55	1.61	1.67	1.71	1.78	1.88	1.98	2.07	2.16	2.24	2.32	2.40	$\frac{3}{8}$
$\frac{1}{2}$	1.12	1.22	1.32	1.41	1.50	1.58	1.66	1.73	1.80	1.87	1.93	2.00	2.07	2.18	2.29	2.39	2.50	2.60	2.69	2.78	$\frac{1}{2}$
$\frac{5}{8}$	1.28	1.40	1.50	1.60	1.70	1.79	1.88	1.96	2.04	2.11	2.19	2.26	2.32	2.46	2.58	2.69	2.80	2.92	3.02	3.12	$\frac{5}{8}$
$\frac{3}{4}$	1.44	1.56	1.67	1.78	1.89	1.98	2.08	2.16	2.25	2.33	2.41	2.48	2.56	2.70	2.84	2.96	3.09	3.21	3.32	3.43	$\frac{3}{4}$
$\frac{7}{8}$	1.59	1.72	1.84	1.95	2.06	2.16	2.26	2.36	2.45	2.54	2.62	2.70	2.78	2.94	3.08	3.22	3.38	3.50	3.63	3.75	$\frac{7}{8}$
1	1.73	1.87	2.00	2.12	2.23	2.34	2.45	2.55	2.64	2.74	2.82	2.91	3.00	3.16	3.31	3.46	3.61	3.74	3.87	4.00	1
$1\frac{1}{8}$	1.87	2.02	2.15	2.28	2.40	2.51	2.62	2.73	2.83	2.93	3.02	3.11	3.21	3.37	3.53	3.69	3.84	3.98	4.12	4.26	$1\frac{1}{8}$
$1\frac{1}{4}$	2.01	2.16	2.30	2.43	2.56	2.68	2.80	2.90	3.01	3.11	3.22	3.31	3.40	3.58	3.75	3.91	4.07	4.22	4.37	4.51	$1\frac{1}{4}$
$1\frac{3}{8}$	2.16	2.31	2.45	2.59	2.72	2.84	2.96	3.08	3.18	3.29	3.39	3.49	3.59	3.77	3.95	4.12	4.28	4.44	4.59	4.74	$1\frac{3}{8}$
$1\frac{1}{2}$	2.29	2.45	2.60	2.74	2.87	3.00	3.12	3.24	3.36	3.46	3.58	3.67	3.77	3.97	4.15	4.33	4.50	4.66	4.82	4.97	$1\frac{1}{2}$
$1\frac{5}{8}$	2.42	2.59	2.74	2.89	3.02	3.15	3.28	3.40	3.52	3.63	3.74	3.85	3.95	4.15	4.34	4.53	4.70	4.87	5.03	5.20	$1\frac{5}{8}$
$1\frac{3}{4}$	2.56	2.72	2.88	3.03	3.17	3.30	3.43	3.56	3.68	3.80	3.91	4.03	4.14	4.34	4.54	4.73	4.90	5.08	5.25	5.42	$1\frac{3}{4}$
$1\frac{7}{8}$	2.70	2.86	3.02	3.18	3.32	3.46	3.59	3.72	3.84	3.97	4.08	4.20	4.30	4.52	4.71	4.91	5.10	5.28	5.45	5.62	$1\frac{7}{8}$
2	2.83	3.00	3.16	3.31	3.46	3.61	3.75	3.87	4.00	4.12	4.24	4.36	4.47	4.69	4.90	5.10	5.29	5.48	5.65	5.83	2
$2\frac{1}{8}$	2.96	3.13	3.30	3.46	3.61	3.75	3.89	4.02	4.16	4.28	4.40	4.52	4.64	4.86	5.08	5.28	5.48	5.67	5.85	6.03	$2\frac{1}{8}$
$2\frac{1}{4}$	3.09	3.27	3.44	3.60	3.75	3.90	4.04	4.18	4.31	4.44	4.56	4.68	4.80	5.03	5.25	5.46	5.66	5.86	6.05	6.23	$2\frac{1}{4}$
$2\frac{3}{8}$	3.22	3.40	3.57	3.74	3.89	4.04	4.18	4.32	4.46	4.59	4.72	4.84	4.96	5.20	5.42	5.64	5.84	6.04	6.24	6.42	$2\frac{3}{8}$
$2\frac{1}{2}$	3.35	3.54	3.71	3.87	4.03	4.18	4.33	4.47	4.61	4.74	4.87	5.00	5.12	5.36	5.59	5.81	6.02	6.22	6.42	6.61	$2\frac{1}{2}$
$2\frac{5}{8}$	3.48	3.67	3.84	4.01	4.17	4.32	4.47	4.62	4.76	4.89	5.03	5.15	5.28	5.52	5.76	5.98	6.20	6.40	6.61	6.80	$2\frac{5}{8}$
$2\frac{3}{4}$	3.61	3.80	3.98	4.15	4.31	4.47	4.62	4.76	4.90	5.04	5.18	5.31	5.44	5.68	5.92	6.15	6.37	6.58	6.79	6.99	$2\frac{3}{4}$
$2\frac{7}{8}$	3.75	3.93	4.11	4.28	4.45	4.60	4.76	4.91	5.05	5.19	5.33	5.46	5.59	5.84	6.08	6.32	6.54	6.76	6.96	7.17	$2\frac{7}{8}$

Approximate blank sizes given above are figured from the formula $D = \sqrt{d^2 + 4dh}$; D = diam. of blank; d = diam. of shell; h = height of shell.

NOTE.—Blank sizes given are approximate only; they do not include any allowance for stretch of metal and are figured without reference to thickness of metal. Shells are figured with sharp corners in the bottom. Diameter of shell should be taken from center of thickness of side walls. Sizes of blanks for shells vary according to the varying conditions of die construction—such as fit of die and punch in relation to each other, the size of drawing corner on the die or punch, or amount of pressure on blank-holding surfaces. The character of metal, whether sheet steel, brass, copper, aluminum, nickel, zinc, silver or gold, and its qualities as regards hardness or softness also have a determining influence.

TABLE 2 (*Continued*).—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From ¼ In. Diameter by 4 In. High to 2⅞ In. Diameter by 12 In. High

Diameter of shell	Height of shell: 4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	Diameter of shell
¼	2.02	2.08	2.13	2.20	2.25	2.31	2.36	2.41	2.46	2.56	2.66	2.75	2.83	2.93	3.01	[illegible]	3.17	[illegible]	[illegible]	3.40	3.48	¼
⅜	2.48	2.55	2.63	2.70	2.76	2.83	2.90	2.96	3.03	3.15	3.27	3.38	3.48	3.59	3.70	3.80	3.90	3.98	4.08	4.17	4.26	⅜
½	2.88	[illegible]	3.04	3.12	3.20	3.28	3.35	3.42	3.50	3.64	3.77	3.90	4.03	4.15	[illegible]	4.39	4.50	4.61	4.71	4.82	4.93	½
⅝	3.23	3.32	3.42	3.50	3.59	3.68	3.76	3.84	3.92	4.08	4.23	4.38	4.52	4.65	4.78	4.91	5.04	5.16	5.28	5.39	5.51	⅝
¾	3.54	3.65	3.75	3.85	3.94	4.03	4.13	4.22	4.30	4.48	4.64	4.80	4.96	5.10	5.25	5.39	5.53	5.66	5.79	[illegible]	6.05	¾
⅞	3.84	3.95	4.06	4.17	4.27	4.38	4.47	4.57	4.66	4.84	5.03	5.19	5.36	5.52	5.68	5.83	5.98	6.12	6.26	6.40	6.53	⅞
1	4.13	4.24	4.35	4.46	4.58	4.69	4.79	4.89	5.00	5.19	5.39	5.57	5.74	5.92	6.08	6.24	6.40	6.56	6.71	6.86	7.00	1
1⅛	4.39	4.51	4.63	4.75	4.87	4.98	5.10	5.21	5.31	5.52	5.72	5.92	6.10	6.28	6.46	6.63	6.80	6.96	7.12	7.28	7.43	1⅛
1¼	4.65	4.78	4.90	5.03	5.15	5.27	5.39	5.50	5.61	5.84	6.04	6.25	6.45	6.64	6.82	7.00	7.18	7.35	[illegible]	7.68	7.84	1¼
1⅜	4.88	5.02	5.16	5.29	5.42	5.54	5.67	5.79	5.90	6.13	6.35	6.57	6.78	6.97	7.16	7.35	7.54	7.73	7.89	8.07	8.24	1⅜
1½	5.12	5.26	5.40	5.54	5.68	5.81	5.93	6.07	6.19	6.42	6.65	6.87	7.09	7.30	7.50	7.70	7.89	8.08	8.26	8.44	8.62	1½
1⅝	5.35	5.50	5.64	5.78	5.92	6.06	6.20	6.33	6.45	6.70	6.94	7.17	7.39	7.61	7.82	8.02	8.22	8.42	8.61	8.80	8.98	1⅝
1¾	5.57	5.72	5.88	6.02	6.17	6.31	6.45	6.58	6.71	6.97	7.22	7.46	7.69	7.91	8.13	8.34	8.55	8.75	8.95	9.14	9.33	1¾
1⅞	5.79	5.95	6.10	6.25	6.41	6.55	6.69	6.83	6.96	7.23	7.49	7.73	7.97	8.20	8.43	8.64	8.86	9.07	9.27	9.48	9.67	1⅞
2	6.00	6.16	6.32	6.48	6.63	6.78	6.93	7.07	7.21	7.49	7.75	8.00	8.25	8.48	8.72	8.94	9.17	9.38	9.59	9.80	10.00	2
2⅛	6.21	6.38	6.54	6.70	6.86	7.01	7.16	7.31	7.45	7.73	8.00	8.26	8.52	8.76	9.00	9.23	9.46	9.68	9.90	10.11	10.32	2⅛
2¼	6.41	6.58	6.75	6.91	7.08	7.23	7.39	7.54	7.68	7.97	8.25	8.52	8.78	9.03	9.28	9.52	9.75	9.98	10.21	10.42	10.63	2¼
2⅜	6.61	6.78	6.96	7.13	7.29	7.45	7.61	7.76	7.91	8.21	8.49	8.77	9.03	9.29	9.55	9.79	10.03	10.26	10.49	10.72	10.94	2⅜
2½	6.80	6.98	7.16	7.33	7.50	7.66	7.82	7.98	8.14	8.44	8.73	9.01	9.29	9.55	9.81	10.06	10.31	10.55	10.78	11.01	11.24	2½
2⅝	6.99	7.18	7.36	7.53	7.71	7.88	8.04	8.20	8.36	8.67	8.97	9.25	9.53	9.80	10.07	10.33	10.58	10.82	11.06	11.30	11.53	2⅝
2¾	7.18	7.37	7.55	7.73	7.91	8.08	8.25	8.41	8.58	8.89	9.20	9.49	9.78	10.05	10.32	10.59	10.84	11.09	11.33	11.58	11.81	2¾
2⅞	7.37	7.56	7.75	7.93	8.11	8.29	8.46	8.62	8.79	9.11	9.42	9.72	10.01	10.29	10.57	10.84	11.11	11.35	11.61	11.85	12.09	2⅞

TABLE 2 (*Continued*).—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS
From 3 In. Diameter by ½ In. High to 5⅞ In. Diameter by 3¾ In. High

Diameter of shell	Height of shell ½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3	3¼	3½	3¾	Diameter of shell
3	3.87	4.06	4.24	4.42	4.58	4.74	4.90	5.05	5.20	5.34	5.48	5.61	5.74	6.00	6.25	6.48	6.71	6.93	7.14	7.35	3
3⅛	4.00	4.19	4.38	4.55	4.72	4.88	5.04	5.19	5.34	5.48	5.63	5.76	5.90	6.16	6.40	6.64	6.87	7.10	7.32	7.52	3⅛
3¼	4.13	4.32	4.51	4.68	4.85	5.02	5.18	5.33	5.48	5.63	5.77	5.91	6.05	6.31	6.56	6.80	7.04	7.26	7.48	7.70	3¼
3⅜	4.26	4.45	4.64	4.82	4.99	5.15	5.31	5.47	5.62	5.77	5.92	6.05	6.19	6.47	6.72	6.96	7.20	7.43	7.66	7.87	3⅜
3½	4.39	4.58	4.77	4.95	5.12	5.29	5.45	5.61	5.77	5.91	6.06	6.20	6.35	6.61	6.87	7.12	7.37	7.60	7.83	8.05	3½
3⅝	4.51	4.71	4.90	5.08	5.26	5.43	5.59	5.75	5.90	6.06	6.21	6.35	6.49	6.76	7.03	7.28	7.52	7.76	7.99	8.21	3⅝
3¾	4.64	4.84	5.03	5.21	5.39	5.56	5.73	5.89	6.04	6.20	6.35	6.49	6.63	6.91	7.18	7.43	7.68	7.92	8.16	8.38	3¾
3⅞	4.77	4.97	5.16	5.34	5.52	5.69	5.86	6.02	6.18	6.34	6.49	6.64	6.78	7.06	7.33	7.59	7.84	8.08	8.32	8.55	3⅞
4	4.90	5.10	5.29	5.48	5.66	5.83	6.00	6.16	6.32	6.48	6.63	6.78	6.92	7.21	7.48	7.74	8.00	8.24	8.48	8.71	4
4⅛	5.02	5.22	5.42	5.61	5.79	5.96	6.13	6.30	6.46	6.62	6.77	6.92	7.07	7.36	7.63	7.89	8.15	8.40	8.64	8.88	4⅛
4¼	5.15	5.35	5.55	5.74	5.92	6.09	6.27	6.43	6.60	6.76	6.91	7.06	7.21	7.50	7.78	8.05	8.31	8.56	8.80	9.04	4¼
4⅜	5.28	5.48	5.68	5.87	6.05	6.23	6.40	6.57	6.73	6.89	7.05	7.21	7.35	7.64	7.93	8.20	8.46	8.71	8.96	9.20	4⅜
4½	5.40	5.61	5.81	6.00	6.18	6.36	6.53	6.70	6.87	7.03	7.19	7.35	7.50	7.79	8.07	8.35	8.61	8.87	9.12	9.36	4½
4⅝	5.53	5.74	5.93	6.13	6.31	6.49	6.67	6.84	7.01	7.17	7.33	7.48	7.64	7.93	8.22	8.50	8.76	9.02	9.28	9.52	4⅝
4¾	5.66	5.86	6.06	6.26	6.44	6.62	6.80	6.97	7.14	7.31	7.47	7.62	7.78	8.08	8.37	8.64	8.91	9.18	9.43	9.68	4¾
4⅞	5.78	5.99	6.19	6.39	6.57	6.76	6.93	7.11	7.28	7.44	7.60	7.76	7.92	8.22	8.51	8.79	9.06	9.33	9.59	9.84	4⅞
5	5.91	6.12	6.32	6.52	6.70	6.89	7.07	7.24	7.41	7.58	7.74	7.90	8.06	8.36	8.66	8.94	9.21	9.48	9.74	10.00	5
5⅛	6.04	6.25	6.45	6.64	6.83	7.02	7.20	7.37	7.55	7.72	7.88	8.04	8.21	8.51	8.80	9.09	9.37	9.63	9.90	10.15	5⅛
5¼	6.17	6.37	6.58	6.77	6.96	7.15	7.33	7.51	7.68	7.85	8.02	8.18	8.34	8.65	8.94	9.23	9.51	9.78	10.05	10.31	5¼
5⅜	6.29	6.50	6.71	6.90	7.09	7.28	7.46	7.64	7.82	7.99	8.15	8.31	8.48	8.79	9.09	9.38	9.66	9.93	10.20	10.46	5⅜
5½	6.42	6.63	6.83	7.03	7.22	7.41	7.60	7.77	7.95	8.12	8.29	8.45	8.61	8.93	9.23	9.52	9.81	10.08	10.35	10.62	5½
5⅝	6.54	6.76	6.96	7.16	7.35	7.54	7.73	7.91	8.08	8.25	8.42	8.59	8.75	9.07	9.37	9.67	9.95	10.23	10.50	10.77	5⅝
5¾	6.67	6.88	7.09	7.29	7.48	7.67	7.86	8.04	8.22	8.39	8.56	8.72	8.89	9.20	9.51	9.81	10.10	10.38	10.65	10.92	5¾
5⅞	6.80	7.01	7.22	7.42	7.61	7.80	7.99	8.17	8.35	8.52	8.69	8.86	9.02	9.34	9.65	9.95	10.24	10.52	10.80	11.07	5⅞

TABLE 2 (*Continued*).—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS
From 3 In. Diameter by 4 In. High to 5⅞ In. Diameter by 12 In. High

Diameter of shell	Height of shell																					Diameter of shell
	4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	
3	7.55	7.75	7.94	8.12	8.30	8.48	8.66	8.83	9.00	9.33	9.64	9.95	10.25	10.53	10.82	[illegible]	11.36	11.62	11.87	12.12	12.37	3
3⅛	7.73	7.93	8.12	8.31	8.50	8.68	8.86	9.03	9.20	9.54	9.86	10.17	10.48	10.77	11.06	11.34	11.61	11.88	12.13	12.39	12.64	3⅛
3¼	7.91	[illegible]	8.31	8.50	8.69	8.88	9.06	9.23	9.41	9.75	10.08	10.40	10.70	11.00	11.29	11.58	11.86	[illegible]	12.39	12.65	12.90	3¼
3⅜	8.08	8.29	8.49	8.69	8.88	9.07	9.25	9.43	9.61	9.96	10.29	10.61	10.93	11.23	11.53	11.82	12.10	12.37	12.64	[illegible]	13.17	3⅜
3½	8.26	8.47	8.68	8.87	9.06	9.26	9.45	9.63	9.81	10.16	10.50	10.83	11.15	11.46	11.76	12.05	12.34	12.62	12.89	[illegible]	13.43	3½
3⅝	8.43	8.65	8.85	9.06	9.25	9.45	9.64	9.82	10.00	10.36	10.71	11.04	11.36	11.68	11.98	12.28	12.57	12.86	13.14	13.41	13.68	3⅝
3¾	8.60	8.82	9.03	9.23	9.44	9.63	9.82	10.01	10.20	10.56	10.91	11.25	11.58	11.90	12.21	12.51	12.80	13.09	13.37	13.65	13.93	3¾
3⅞	8.77	8.99	9.20	9.41	9.61	9.82	10.01	10.20	10.39	10.76	11.11	11.45	11.79	12.11	12.43	12.74	13.04	13.33	13.62	13.90	14.18	3⅞
4	8.94	9.16	9.38	9.59	9.79	10.00	10.20	10.39	10.58	10.95	11.31	11.66	12.00	12.33	12.65	12.96	13.26	13.56	13.85	14.14	14.42	4
4⅛	9.11	9.33	9.55	9.76	9.97	10.18	10.38	10.57	10.76	11.14	11.51	11.86	12.20	12.54	12.86	13.18	13.49	13.79	14.09	14.38	14.66	4⅛
4¼	9.27	9.50	9.72	9.94	10.15	10.35	10.56	10.76	10.95	11.33	11.71	12.06	12.41	12.75	13.07	13.40	13.72	14.02	14.32	14.61	14.90	4¼
4⅜	9.44	9.67	9.89	10.11	10.32	10.53	10.74	10.94	11.14	11.52	11.90	12.26	12.61	12.95	13.29	13.61	13.93	14.24	14.54	14.84	15.13	4⅜
4½	9.60	9.83	10.06	10.28	10.50	10.71	10.92	11.12	11.32	11.71	12.09	12.45	12.81	13.16	13.50	13.82	14.15	14.45	14.77	15.07	15.37	4½
4⅝	9.76	10.00	10.22	10.45	10.67	10.88	11.09	11.30	11.50	11.90	12.28	12.65	13.01	13.36	13.70	14.04	14.36	14.68	14.99	15.30	15.60	4⅝
4¾	9.92	10.16	10.39	10.62	10.84	11.05	11.27	11.47	11.68	12.08	12.47	12.84	13.21	13.56	13.91	14.25	14.57	14.90	15.22	15.52	15.83	4¾
4⅞	10.08	10.32	10.55	10.78	11.01	11.23	11.44	11.65	11.86	12.26	12.65	13.03	13.41	13.76	14.11	14.45	14.79	15.11	15.43	15.74	16.05	4⅞
5	10.24	10.48	10.72	10.95	11.18	11.40	11.61	11.83	12.04	12.45	12.84	13.23	13.60	13.96	14.32	14.66	15.00	15.33	15.65	15.97	16.28	5
5⅛	10.40	10.65	10.88	11.12	11.34	11.57	11.79	12.00	12.21	12.63	13.03	13.41	13.79	14.16	14.52	14.86	15.21	15.54	15.87	16.19	16.50	5⅛
5¼	10.56	10.80	11.04	11.28	11.51	11.74	11.96	12.17	12.39	12.81	13.21	13.60	13.98	14.35	14.71	15.07	15.41	15.75	16.08	16.40	16.72	5¼
5⅜	10.72	10.96	11.20	11.44	11.68	11.90	12.13	12.35	12.56	12.98	13.39	13.79	14.17	14.54	14.91	15.27	15.61	15.95	16.29	16.61	16.93	5⅜
5½	10.87	11.12	11.36	11.60	11.84	12.07	12.29	12.52	12.73	13.16	13.57	13.97	14.36	14.73	15.11	15.47	15.82	16.16	16.50	16.83	17.15	5½
5⅝	11.02	11.28	11.52	11.76	12.00	12.23	12.46	12.69	12.90	13.33	13.75	14.15	14.54	14.93	15.30	15.66	16.02	16.36	16.70	17.04	17.36	5⅝
5¾	11.18	11.43	11.68	11.92	12.16	12.40	12.63	12.85	13.07	13.51	13.93	14.33	14.73	15.11	15.49	15.86	16.21	16.57	16.91	17.25	17.58	5¾
5⅞	11.33	11.59	11.84	12.08	12.32	12.56	12.79	13.02	13.24	13.68	14.10	14.51	14.91	15.30	15.68	16.05	16.42	16.77	17.11	17.45	17.79	5⅞

TABLE 2 (*Continued*).—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS
From 6 In. Diameter by ½ In. High to 12 In. Diameter by 3¾ In. High

Diameter of shell	Height of shell																				Diameter of shell
	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3	3¼	3½	3¾	
6	6.92	7.14	7.34	7.55	7.74	7.93	8.12	8.30	8.48	8.66	8.83	9.00	9.16	9.48	9.79	10.09	10.39	10.67	10.95	11.22	6
6¼	7.18	7.39	7.60	7.80	8.00	8.19	8.38	8.57	8.75	8.92	9.10	9.27	9.44	9.76	10.07	10.38	10.68	10.96	11.25	11.52	6¼
6½	7.43	7.64	7.85	8.06	8.26	8.45	8.64	8.83	9.01	9.19	9.36	9.54	9.71	10.03	10.35	10.66	10.96	11.25	11.54	11.82	6½
6¾	7.68	7.90	8.11	8.31	8.51	8.71	8.90	9.09	9.27	9.45	9.63	9.80	9.97	10.31	10.63	10.94	11.25	11.54	11.83	12.11	6¾
7	7.93	8.15	8.36	8.57	8.77	8.97	9.16	9.35	9.53	9.72	9.90	10.07	10.24	10.58	10.90	11.22	11.53	11.83	12.12	12.40	7
7¼	8.18	8.40	8.62	8.82	9.03	9.22	9.42	9.61	9.80	9.98	10.16	10.34	10.51	10.85	11.18	11.50	11.81	12.11	12.41	12.70	7¼
7½	8.44	8.66	8.87	9.08	9.28	9.48	9.68	9.87	10.06	10.24	10.42	10.60	10.78	11.12	11.45	11.77	12.09	12.39	12.69	12.99	7½
7¾	8.69	8.91	9.12	9.33	9.54	9.74	9.94	10.13	10.32	10.50	10.69	10.87	11.04	11.39	11.72	12.05	12.37	12.68	12.98	13.27	7¾
8	8.94	9.16	9.38	9.59	9.79	10.00	10.19	10.39	10.58	10.77	10.95	11.13	11.31	11.66	11.99	12.32	12.64	12.96	13.26	13.56	8
8¼	9.19	9.41	9.63	9.84	10.05	10.25	10.45	10.65	10.84	11.03	11.21	11.39	11.57	11.92	12.27	12.60	12.92	13.23	13.54	13.84	8¼
8½	9.44	9.66	9.88	10.10	10.30	10.51	10.71	10.90	11.10	11.29	11.47	11.66	11.84	12.19	12.53	12.87	13.20	13.51	13.82	14.13	8½
8¾	9.69	9.92	10.13	10.35	10.56	10.76	10.96	11.16	11.36	11.55	11.73	11.92	12.10	12.46	12.80	13.14	13.47	13.79	14.10	14.41	8¾
9	9.95	10.17	10.39	10.60	10.81	11.02	11.21	11.42	11.61	11.81	11.99	12.18	12.36	12.72	13.07	13.41	13.74	14.07	14.38	14.69	9
9¼	10.20	10.42	10.64	10.85	11.07	11.27	11.48	11.68	11.87	12.07	12.26	12.44	12.63	12.99	13.34	13.68	14.02	14.34	14.66	14.97	9¼
9½	10.45	10.67	10.89	11.11	11.32	11.53	11.73	11.93	12.13	12.32	12.52	12.70	12.89	13.25	13.61	13.95	14.29	14.61	14.94	15.25	9½
9¾	10.70	10.92	11.14	11.36	11.57	11.78	11.99	12.19	12.39	12.58	12.77	12.96	13.15	13.52	13.87	14.22	14.56	14.89	15.21	15.53	9¾
10	10.95	11.18	11.40	11.61	11.83	12.04	12.24	12.44	12.64	12.84	13.03	13.22	13.41	13.78	14.14	14.49	14.83	15.16	15.49	15.81	10
10¼	11.20	11.43	11.65	11.87	12.08	12.29	12.50	12.70	12.90	13.10	13.29	13.48	13.67	14.04	14.40	14.75	15.10	15.43	15.76	16.08	10¼
10½	11.45	11.68	11.90	12.12	12.33	12.54	12.75	12.96	13.16	13.36	13.55	13.74	13.93	14.30	14.66	15.02	15.36	15.70	16.03	16.36	10½
10¾	11.70	11.93	12.15	12.37	12.59	12.80	13.01	13.21	13.41	13.61	13.81	14.00	14.19	14.56	14.93	15.29	15.63	15.97	16.31	16.63	10¾
11	11.95	12.18	12.40	12.62	12.84	13.05	13.26	13.47	13.67	13.87	14.07	14.26	14.45	14.83	15.19	15.55	15.90	16.24	16.58	16.91	11
11¼	12.20	12.43	12.67	12.91	13.09	13.30	13.52	13.72	13.93	14.13	14.33	14.52	14.71	15.08	15.46	15.82	16.17	16.52	16.84	17.17	11¼
11½	12.45	12.65	12.90	13.11	13.35	13.56	13.77	13.98	14.18	14.38	14.58	14.78	14.97	15.35	15.72	16.08	16.43	16.78	17.11	17.45	11½
11¾	12.66	12.92	13.16	13.39	13.59	13.82	14.03	14.23	14.44	14.63	14.84	15.04	15.22	15.60	15.98	16.34	16.70	17.05	17.39	17.73	11¾
12	12.96	13.20	13.42	13.63	13.86	14.07	14.28	14.49	14.70	14.88	15.10	15.30	15.50	15.88	16.24	16.61	16.96	17.32	17.66	18.00	12

TABLE 2 (*Continued*).—APPROXIMATE DIAMETER OF BLANKS FOR SHELLS
From 6 In. Diameter by 4 In. High to 12 In. Diameter by 12 In. High

Diameter of shell	Height of shell																					Diameter of shell
	4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	
6	11.48	11.74	12.00	12.24	12.48	12.72	12.96	13.19	13.41	13.85	14.28	14.69	15.10	15.49	15.87	16.24	16.61	16.97	17.32	17.66	18.00	6
6¼	11.79	12.05	12.31	12.56	12.80	13.05	13.28	13.52	13.74	14.19	14.63	15.05	15.46	15.86	16.25	16.63	17.00	17.36	17.72	18.07	18.41	6¼
6½	12.09	12.36	12.62	12.87	13.12	13.37	13.61	13.85	14.08	14.53	14.97	15.40	15.82	16.22	16.62	17.00	17.38	17.75	18.11	18.47	18.82	6½
6¾	12.39	12.66	12.92	13.18	13.43	13.68	13.93	14.17	14.40	14.86	15.31	15.75	16.17	16.58	16.98	17.38	17.76	18.14	18.50	18.87	19.22	6¾
7	12.68	12.96	13.23	13.49	13.74	14.00	14.24	14.49	14.73	15.19	15.65	16.09	16.52	16.94	17.34	17.74	18.13	18.52	18.89	19.26	19.62	7
7¼	12.98	13.25	13.52	13.79	14.05	14.31	14.56	14.80	15.05	15.52	15.98	16.43	16.86	17.29	17.70	18.11	18.51	18.89	19.27	19.64	20.01	7¼
7½	13.27	13.55	13.82	14.09	14.36	14.62	14.87	15.12	15.37	15.85	16.31	16.77	17.21	17.64	18.06	18.47	18.87	19.26	19.65	20.03	20.40	7½
7¾	13.56	13.84	14.12	14.39	14.66	14.92	15.18	15.43	15.68	16.17	16.64	17.10	17.55	17.98	18.41	18.82	19.23	19.63	20.02	20.40	20.78	7¾
8	13.85	14.14	14.42	14.69	14.96	15.23	15.49	15.74	15.99	16.49	16.97	17.43	17.88	18.33	18.76	19.18	19.59	19.99	20.39	20.78	21.16	8
8¼	14.14	14.43	14.71	14.99	15.26	15.53	15.79	16.05	16.31	16.80	17.29	17.76	18.22	18.66	19.10	19.53	19.95	20.36	20.76	21.15	21.54	8¼
8½	14.43	14.72	15.00	15.28	15.56	15.83	16.10	16.36	16.62	17.12	17.61	18.09	18.55	19.00	19.44	19.88	20.30	20.71	21.11	21.51	21.91	8½
8¾	14.71	15.00	15.29	15.58	15.86	16.13	16.40	16.66	16.92	17.43	17.93	18.41	18.88	19.34	19.78	20.22	20.65	21.07	21.48	21.88	22.28	8¾
9	14.99	15.29	15.58	15.87	16.15	16.43	16.70	16.97	17.23	17.74	18.24	18.73	19.20	19.67	20.12	20.56	21.00	21.42	21.84	22.24	22.64	9
9¼	15.28	15.58	15.87	16.16	16.44	16.72	17.00	17.26	17.53	18.05	18.56	19.05	19.53	20.00	20.45	20.90	21.34	21.77	22.19	22.60	23.00	9¼
9½	15.56	15.86	16.16	16.45	16.74	17.02	17.29	17.57	17.83	18.36	18.87	19.37	19.85	20.32	20.79	21.24	21.68	22.11	22.54	22.96	23.37	9½
9¾	15.84	16.14	16.44	16.74	17.03	17.31	17.59	17.86	18.14	18.66	19.18	19.68	20.17	20.65	21.12	21.57	22.02	22.46	22.89	23.31	23.72	9¾
10	16.12	16.43	16.73	17.02	17.31	17.60	17.88	18.16	18.43	18.97	19.49	20.00	20.49	20.97	21.44	21.90	22.36	22.80	23.24	23.66	24.08	10
10¼	16.40	16.71	17.01	17.31	17.60	17.89	18.18	18.46	18.73	19.27	19.80	20.31	20.81	21.29	21.77	22.23	22.69	23.14	23.58	24.01	24.43	10¼
10½	16.68	16.99	17.29	17.59	17.89	18.18	18.47	18.75	19.03	19.57	20.10	20.62	21.12	21.61	22.09	22.56	23.02	23.47	23.92	24.35	24.78	10½
10¾	16.95	17.27	17.58	17.88	18.18	18.47	18.76	19.04	19.32	19.87	20.40	20.93	21.43	21.93	22.41	22.89	23.35	23.81	24.25	24.69	25.13	10¾
11	17.23	17.55	17.86	18.16	18.46	18.76	19.05	19.33	19.62	20.17	20.71	21.23	21.74	22.24	22.73	23.21	23.68	24.14	24.59	25.04	25.47	11
11¼	17.50	17.81	18.12	18.44	18.74	19.03	19.33	19.62	19.90	20.46	21.01	21.54	22.05	22.55	23.06	23.54	24.00	24.47	24.92	25.37	25.82	11¼
11½	17.78	18.09	18.41	18.71	19.02	19.32	19.63	19.92	20.20	20.76	21.30	21.84	22.36	22.87	23.36	23.85	24.33	24.80	25.25	25.70	26.15	11½
11¾	18.05	18.38	18.70	19.01	19.32	19.61	19.90	20.21	20.50	21.05	21.61	22.14	22.67	23.18	23.68	24.17	24.66	25.13	25.58	26.04	26.49	11¾
12	18.33	18.64	18.97	19.28	19.59	19.89	20.20	20.49	20.77	21.35	21.90	22.45	22.97	23.50	23.99	24.48	24.97	25.45	25.93	26.37	26.84	12

$1\frac{1}{2}$ in. specified, say $1\frac{15}{32}$ in. Draw line E through the corners of C and D and scribe the required radius of one inch.

In the *American Machinist's Handbook* we find that for a shell 1 in. in diameter and $1\frac{1}{2}$ in. high the blank diameter given is 2.65 in., which is obtained from the formula

$$D = \sqrt{d(d + 4h)}$$

where

D = Blank diameter,
d = Diameter of finished shell,
h = Height of finished shell,

or it may be expressed as follows: Add diameter of finished shell to four times its height; multiply this result by the diameter of the finished shell

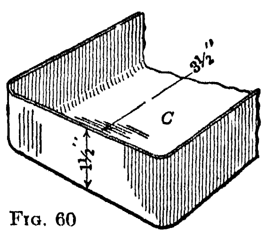


Fig. 60

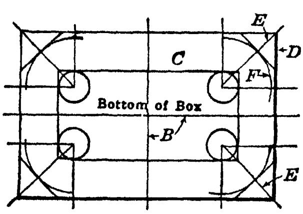


Fig. 61

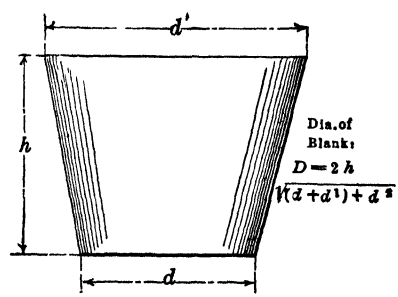


Fig. 62

Figs. 60–62.

and extract the square root of the product; this root will be the required blank diameter.

With a radius equal to one-half this amount scribe an arc at each corner as at F, and connect this arc to the outer lines D by curved lines, as shown, the radius of which can be made several times larger than the corner radius of finished shell.

After this is done we have a real trial blank, a duplicate of which should be made in case alterations are necessary.

Blanks for Tapered Shells

From the same source referred to above, we have the formula for a tapered shell blank as follows: Fig. 62 shows a taper shell with small diameter of finished shell represented at d, large diameter at d' and blank diameter D, and height h. The formula is then $D = 2h\sqrt{(d + d') + d^2}$.

CHAPTER XXII

LAYING OUT AND MAKING TEMPLETS AND DIES

There are various methods of laying out dies and boring and machining to correct outline. The method selected will vary with the experience of the die maker, the equipment of the tool room where he is employed, the class of work for which the die is to be used, and the corresponding degree of accuracy to which the die must be held in its production.

The methods of one shop may seem crude when compared with the practice elsewhere; on the other hand, the methods of the more exacting tool room may seem unnecessarily refined to those employed in the former shop. Both grades of workmanship are undoubtedly justified in the results demanded of the two distinct classes of shops, and the products of two press rooms are legitimately of different grades of accuracy, just as the work produced in the milling, turning and other machine departments of different plants may justifiably vary in respect to the limits adhered to in accordance with the general character of the article manufactured.

Quality and quantity of output are naturally the two important factors in determining the degree of nicety to which a set of press tools should be held. The same factors are the determining ones in fixing the type and design of the tools as well. Without accurate dies, accurate press work need not be expected, and with tools of improper design and construction satisfactory results in the direction of high production and low cost of up-keep are out of the question.

A great deal of judgment is often necessary to fix the standard to which a set of tools should be held. A small lot of punched parts may be as exacting in the limits of accuracy demanded as a run of work involving a million pieces. Yet where the latter case would justify the expenditure of any necessary amount of time and care in the production of the tools, the same expense for the dies for a small total output might mean nothing better than a very heavy loss on the part of the tool room. Such a condition might suggest the application of some other means altogether for the handling of the work, thus eliminating the making of the press tools entirely for this particular article.

While there are certain classes of expensive machines made up very largely of press made members where the requirements throughout are universally conceded to be exacting and where only the closest workmanship upon the part of the die makers is passed by the inspectors, it is not the case on the other hand that all cheaply marketed apparatus is necessarily produced by cheap tools, of indifferent degree of accuracy. For there are instances where accuracy of parts is not demanded by the

character of the completed article itself, but rather by its very cheapness which necessitates a quality of exactness which will insure all of its parts admitting of assembling with absolutely no delay upon the part of the bench hands, for a few moments of lost time at this point may more than eliminate the narrow margin between total cost of production and the marketable figure to which the completed piece must be held.

These conditions have more than a little to do with the grading of work qualities in the tool room. The experienced die maker will adapt his methods, so far as his equipment permits, to the requirements of each particular set of dies, if he is desirous of seeing the tools progress with the greatest degree of despatch commensurate with the special necessities of each job as it comes to his bench. And this does not mean that he will necessarily turn out at any time what might be called a "sloppy" set of dies, but rather that he will always make the very best tools required for any given grade of work and vary his methods and degrees of refinements to harmonize with the results he wishes to attain.

The process of locating and boring holes in dies and punch plates has been developed along parallel lines to the similar operations involved in the production of high-grade jig work. The use of the vernier height gage in laying off work centers and outlines, the application of the well-known button and master plate methods, the use of verniers and micrometer heads on milling machines and various systems of end and distance gages have all been found of great value in the construction of press tools. There are innumerable instances where such applications as these are as readily made to die work as to the more commonly known classes of jig work where some one or other of the above methods is so frequently resorted to for the locating of hole centers at exact distances. Then, too, the universal dividing head for the miller has its everyday uses on punch and die operations just as it has long been applied to the numerous problems arising in connection with precision tool work in general. An intimate knowledge of the possibilities of the dividing head, including the additional flexibility of this device which has been brought about by the extension of differential indexing, is becoming an almost indispensable part of the die maker's personal equipment.

There are various special machines, as well as attachments for standard tools, that have been developed for die-making as also for general precision tool work. In several instances such equipment has been originated specifically for facilitating the production of tools and dies alone, although like many other lines of tools this equipment has gradually been expanded in its usefulness and it now covers the necessities of other classes of work as well. The jig borer[1] and some other machines are

[1] Complete tables for use with the jig borer for setting accurate location of holes in dies and other tools will be found in the *American Machinists' Handbook*.

examples. Certain types of milling machines, slotters and shapers, slotting attachments, filing machines and so on are cases in point. The precision drilling machine has been found as invaluable for die operations as for jig plate drilling and boring, and the bench lathe with its milling attachment, traverse spindle grinder and other appurtenances, has for long been one of the tools that the die maker cannot dispense with.

It is the purpose of this section to show some of the applications of the foregoing principles and tools to the solution of various interesting problems of the die maker.

Making and Using Simple Templets

An easy and simple way of making templets for use in connection with die work is illustrated by the following engravings:

The dies referred to are of the simple piercing and blanking type commonly known as follow dies, which are to produce blanks similar to the templet shown in Fig. 69. For this piece any dimension can vary 0.004 or 0.005 in.

Several blanks $\frac{1}{16}$ in. thick are wanted for experimental purposes, one to be used as a templet. About the best way to make the first lot by hand is to cut several pieces of material to the proper length and width and clamp them together. Lay off the $\frac{1}{4}$-in. holes 2 in. apart and drill and ream them. Large holes should not be drilled in *single* thin pieces when a *round* hole is required.

The next step is to make the gages shown in Figs. 64 and 65. The gage shown in Fig. 63 is for the $\frac{3}{8}$-in. radius at the ends, and the flat shown on one side is for establishing a line $\frac{9}{32}$ in. each side of the center, which is half the width of the straight part of the link. The gage shown in Fig. 65 is a $\frac{15}{16}$-in. washer $\frac{1}{16}$ in. thick with a $\frac{1}{4}$-in. hole that fits over the stem of the templet, Fig. 64, which should be $\frac{7}{64}$ in. long. It requires only a few minutes to make these pieces and saves a lot of bother later. They should be casehardened in cyanide and used as templets in filing the ends of the work shown in Fig. 63.

In Figs. 66 and 67 is shown the proper way of holding the work to be filed. This finishes the model, and if we have worked with reasonable care up to this point we are ready for the die.

After the steel die block has been surfaced and squared, the face should be treated by heating until a dark-blue color is obtained, or by rubbing with a little clean waste dampened with sulphate of copper solution. Another good surface for a layout is obtained by filing or grinding off all tool marks and rubbing with emery cloth. The rubbing should not be done straight across, but around and around, covering only a small portion at a time. Layout lines are easily seen upon this dull finish.

In Fig. 68 is shown the proper layout for this die.

With a very fine scriber draw the lines B and C, 2 in. apart, crosswise of the steel 1 in. from the center, and a line lengthwise about $\frac{1}{4}$ in. from the center. With the dividers set to $\frac{29}{32}$ in., which is the width of the templet at the large end plus $\frac{1}{16}$ in., which we allow for scrap, lay off E and F, using as centers the intersection of B and C with the lengthwise line. The layout should always be reckoned from the large end of the blank. Figure 69 shows a blank with a clipped ear, the result of the layout shown in Fig. 70.

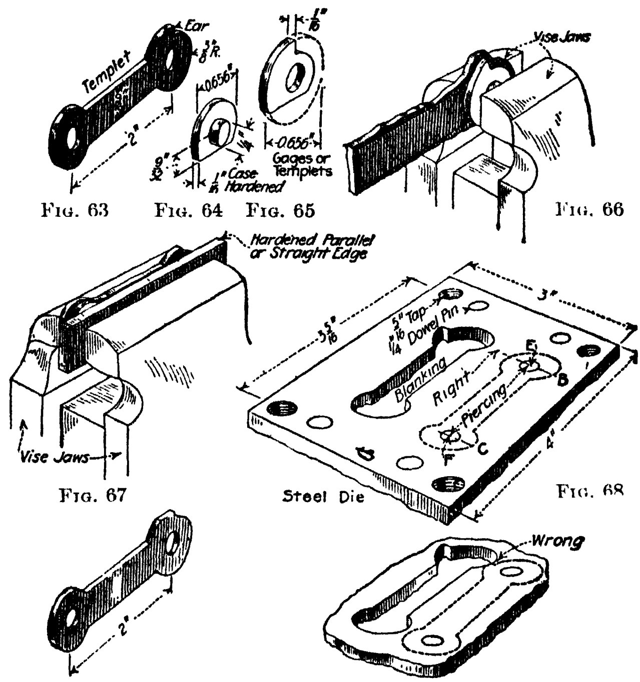


Fig. 63 Fig. 64 Fig. 65 Fig. 66 Fig. 67 Fig. 68 Fig. 69 Fig. 70

Figs. 63-70.—Simple dies and templets.

We could bore this die on the miller without a layout, but we would have to put the clearance in later, so it is best to do it in the lathe, using the compound rest set for $\frac{3}{4}$-degree clearance for the $\frac{3}{4}$-in. holes, and taper-ream the $\frac{1}{4}$-in. holes. The straight part in the middle can be drilled out and finished in the miller or shaper with an extension tool, and the $\frac{15}{32}$-in. radius also. When the screw holes are drilled and tapped and the dowel pin-holes drilled, the die is ready for hardening, after which it is ground on both sides and fitted to the shoe.

A templet should be marked "Die" on one side and "Punch" on the other, as an irregular punch will not fit the die if laid out from the same side of the templet. In laying out the die the surface marked "Die"

should lie next to the steel, using the other side for the punch. As there are several styles of die shoes and punches, the workman should be governed largely by the material furnished. The piercing punch holes in the punch holder are located by drilling through the die from the back, with the blanking punch in place. The most important thing in a follow die is to place the piercing holes in proper relation to the blanking. Then the die becomes a master by which to make and align the punches.

The dotted outline of the blank on Fig. 68 is for the purpose of showing the proper layout.

Some Templet Tools

In Fig. 71 some handy appliances are shown for use in connection with the making and application of templets for dies. In the foreground of this photographic view is a scriber A that is a most useful tool for mark-

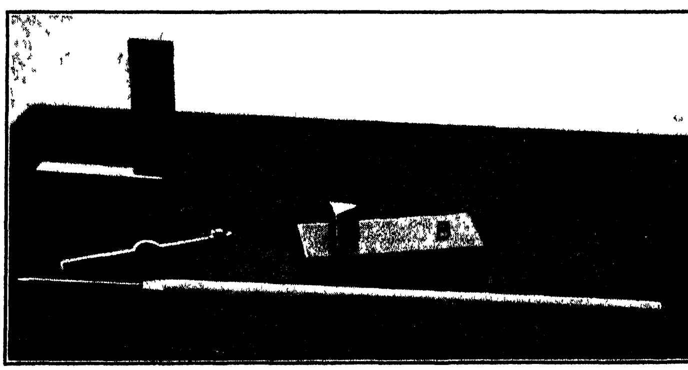


FIG. 71.—Templet tools.

ing with very fine line around the edge of a templet. The handle is $\frac{1}{8}$-in. diameter drill rod with a point inset of $\frac{1}{32}$-in. diameter wire ground to a sharp point that enables lines to be scribed at all points along a templet edge and even in very small corners where the radius is so slight as to make it impossible to follow with anything much coarser than a needle point.

The tool B, with the short vertical post that gives it a resemblance to a die square, is for finishing the edges of templets like the one, say, at C. The base or block is about $2\frac{1}{2}$ in. long by $\frac{1}{4}$ in. thick. It is fitted with a three-cornered post as shown which is made of tool steel and hardened and ground to sharp edges on all three corners. This tool is used as a scraper for removing the slight burr on the edge of the templet and for finishing the edge perfectly square with the flat faces. The tool is held with the templet face resting against the upper face of the block, and when the tool is moved carefully along the edge of the templet it necessarily brings the edge true and square with the templet face.

Laying Out and Roughing Out Dies

The work illustrated in Figs. 63 to 70 covered the working out of a die from a templet where the main portion of the die admitted of working out by simple drilling of the stock and finishing out on the miller or shaper. This slot could in fact have been milled from the enlarged holes already bored at the ends, without preliminary rough drilling if so desired, the process selected depending upon the relative amount of time required by the alternative methods. There are many cases though, where the complete die contour must be outlined and blocked out by rough drilling and the various tools for facilitating this operation are of interest at this point.

Fig 72 —Vernier height gage used in laying out dies.

The die opening may be laid out by a templet as before, or the various working points, center lines, centers of radii, etc., may be laid off on the die block by setting up on an angle plate as in Fig. 72 and applying the vernier height gage as illustrated. With the die block planed square on ends and edges and using a true surface plate as shown, the working lines and centers desired may be laid off accurately and very conveniently.

If, then, the die opening is to be drilled for finishing by shaping, milling, and filing, the simple tools shown below will be found of value in locating the series of hole centers so that the drill will do most of the work, leaving but little stock between for removal afterward. There are

different types of center punches for this class of work. Some die makers use what is known as the spacing center punch, others prefer the type of punch which strikes the center for the drill and at the same time forms a circle by which the punch is set for the next center and so on. This punch undoubtedly simplifies the whole process very appreciably.

Application of the Spacing Center Punch

If the spacing center punch is to be used the solid type shown in Fig. 73 has few equals. A set of four such punches with the punch points $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{3}{8}$ in. apart will cover all requirements for general die work. A set of these punches can be made by any toolmaker in a short time.

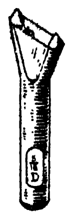


Fig. 73

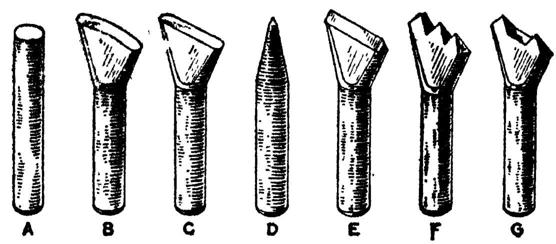


Fig. 74

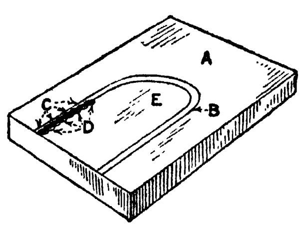


Fig. 75

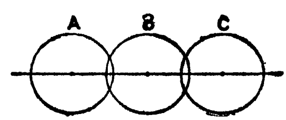


Fig. 76

Figs. 73–76.—The spacing punch and the drilled work.

To describe the various steps from a piece of drill rod to the finished article, we will take for an example a center punch with the spacing points $\frac{1}{4}$ in. apart. A piece of drill rod is cut to a convenient length and one end is rounded as at *A*, Fig. 74. The other end is flattened out as shown at *B*. All the other stages—from *C* to *G*—in making this type of center punch are self-explanatory. An 8-in. mill file and a $\frac{1}{4}$-in. square file are the tools to be used for beveling the flat sides and edges, as at *D* and *E*, and also for filing the nicks. After this has been done, the center portion left by the square file, as shown at *F*, is filed down. The punch will then resemble *G*. The corners left on the two spacing points are now rounded off with a small file, and the punch is ready for hardening. If made of drill rod, it should be hardened, and then drawn to a dark straw color. A spacing center punch is used only to make a small impression for the regular heavy center punch to follow, so there is no danger of the spacing

points breaking off in use. Where a set of spacing center punches of this type has been made, the punches should be stamped on the stem with the size of drill to be used with each punch, as shown in Fig. 73. The sizes can be stamped on after the punches have been hardened and tried out.

A kink worth remembering in drilling stock for parting is illustrated in Fig. 75. The piece *E* is to be removed from the sectional die block *A* by drilling. After a line has been scribed a safe distance from the finish contour of the die, in this case represented by the line *B*, the drill centers are laid out with a spacing center punch and the impression deepened with a regular punch. Every other hole *C* is now drilled clear through the block *A* all the way around. The holes *D* are then drilled the same way, and if the drilling has been properly done, the piece *E* can easily be removed by a few taps with a hammer. The reason for drilling every other hole is to prevent the drill from running off into the next hole. A glance at the layout in Fig. 76 will make clear the point here involved and will demonstrate that the only successful way of drilling holes *A*, *B*, and *C* is to drill holes *A* and *C* first and leave hole *B* for the last.

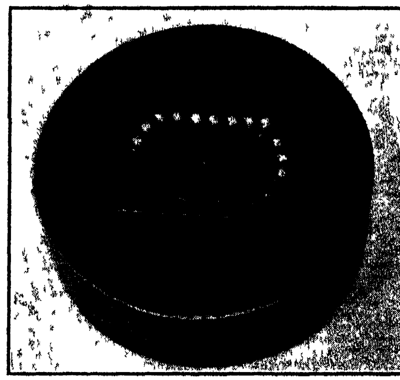


Fig. 77.—Series of holes in drilling out a die opening.

As an actual illustration of a closely drilled die with a minimum of metal in the walls between adjacent holes, the photograph, Fig. 77, is presented here. Examination of the die blank under the microscope will show that only the thinnest wall, a few thousandths of an inch at the most, is left between holes, so that the center is easily knocked out and very little stock left for finishing down to the die outline.

The Circle Marking Center Punch

With the spacing center punch described above it is of course necessary to draw a model line, then a line as a guide for the punch, which means quite a little additional work where the outline is at all irregular. The type of punch which marks its own circle for a guide is made as follows:

Put a piece of drill rod, 0.015 in. larger than the drill to be used, in a spring chuck in the lathe and with a lathe tool or graver form a fine point in the center; also a sharp outer edge, as shown at *A*, Fig. 78. Harden and draw, and it is ready for use.

After drawing the blank outline on the die block, put the sharp edge of the punch on the line and tap lightly, which leaves a center punch mark and circle to which the punch is set for the next hole, as shown at *B*.

After drilling, there is a web left between the holes; to remove this make a drift from drill rod twice the diameter of the drill used minus 0.015 in.; file or mill it on two sides to 0.010 in. thinner than the drill, round the other two sides to approximate the drill radius, put a slight con-

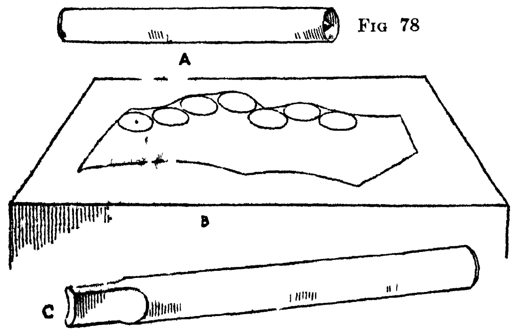


FIG 78

FIG 79

FIGS 78–79 —Spacing center punch and drift

cave in the end, as shown at *C*, Fig 79, harden and draw, and it is ready to use.

To remove, or rather separate, the pieces and at the same time remove the web, drive the drift through the perforated places and the piece will come out and leave 0.0125 in. for finishing.

FIG 80 —Circle-marking center punches.

A set of these center punches for various sizes of circles are represented by Fig. 80. These range from a size which will mark the circle for a $\frac{1}{16}$-in. drill to a size suitable for a $\frac{3}{8}$-in. drill.

DRILLS AND DRIFTS

The half tone, Fig. 81, shows a set of spotting drills for various uses in die-making, including the starting of holes in drilling out dies prior to running twist drills through.

The tools in Fig. 82 are a set of drifts for cutting out the walls between drilled holes as required in removing the stock outlined by the series of holes inside the die contour. These drifts are made in accordance with the experience of many die makers who find that the wedge shaped section of the drift gives a freer cut and enables the drift to clear and free itself as

FIG 81 — Spotting drills

it is driven through the walls between adjacent holes. Most of these drifts are short and without shanks, being formed to uniform shape from end to end and they are therefore stiff and rigid under the action of the hammer applied in making the separating cut.

Some of these drifts will be seen to have a decided angle of slope from back to front of cutting edge and in this case they are adapted for cutting

FIG. 82.—A set of die drifts.

out where holes of different sizes have been drilled as in stocking out the material, between, say, the teeth of a wheel die, where it may be possible to drill two or more holes between top and root of tooth with drills of decidedly different diameters. Wherever there is marked reduction in the width of the slot to be formed, the sharp wedge sectioned drifts are extremely useful.

Working Out the Die Opening

The method of finishing the interior of a die after the stock has been removed from the inside of the drilled outline may be by milling, shaping, and filing, or by a combination of operations on the lathe, miller, shaper, slotter, and filing machine. Frequently the die is of such form as to admit of the grinding of a good share if not all of the interior after it has been

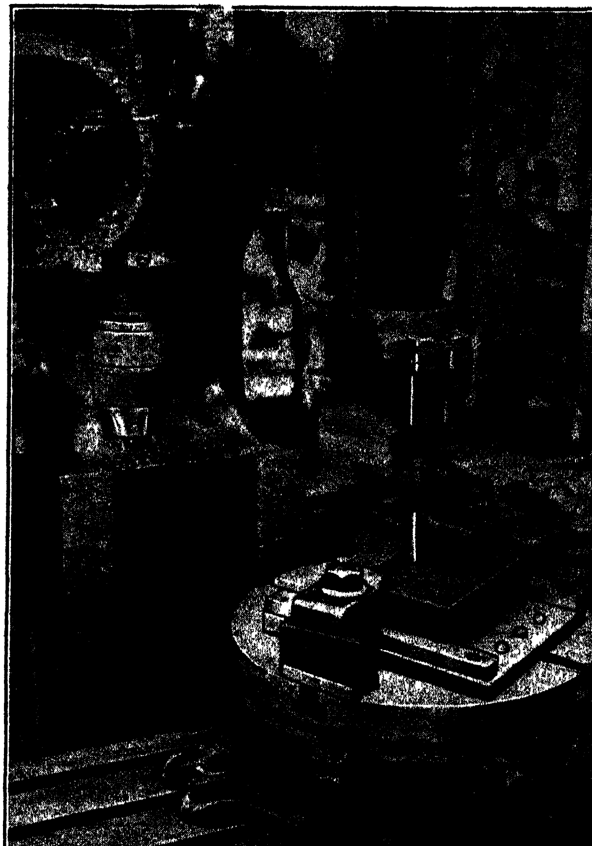


Fig. 83.—Slotting out a die opening.

hardened. This may be done on the regular grinding machine, the internal grinder, or with a traverse spindle grinder, depending upon the size and general character of the work.

A typical example in working out the inside of a die is represented by Fig. 83 which shows the work set up under the adjustable ram of a slotting attachment where the oblong opening of the blanking die and the half round portion at one side are being shaped as indicated. The head for the slotter attachment on this machine is adjustable to give any

desired angle for die clearance, either one-half degree or more according to requirements. The die is shown here, however, secured to an adaptor plate which is itself planed off on the bottom to a half degree slope for general use in machines where adjustment of the tool slide is not possible and so the ram in this instance is set in perpendicular position.

ADVANTAGES OF THE ADAPTOR

This adaptor or sloping holder for the die has been found a convenience in many cases aside from its application to the holding of dies under some

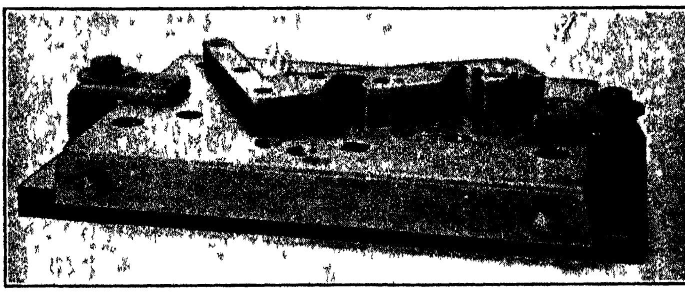


FIG 84 —Adaptor for grinding shear on blanking punch

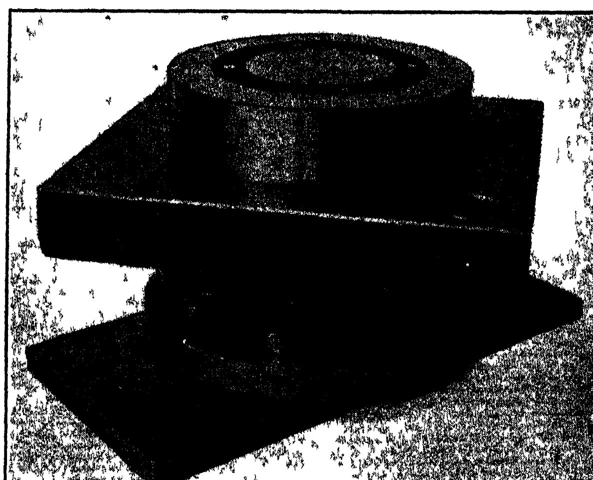


FIG 85 —Method of grinding shear on face of round punch

such condition as that illustrated. For example, when a die or punch is to be ground with shear for facilitating its cutting action the sloping holder enables the work to be set up on the surface grinder and gives at once sufficient angle for the work to be faced to the requisite angle of shear as generally desired. The half degree slope, while seemingly slight, amounts to an actual slope of about 0.009 in. per in. of length so that a punch say, 7 in. across from end to end, would be ground to a total shear

of $\frac{1}{16}$ in. An illustration of this method of using the appliance is given in Fig. 84 where a large blanking punch is seen in place for the grinding of its face to the angle specified.

Another application is seen in the instance of the punch in Fig. 85, which represents a case where a circular disk or washer punch is to be sheared at four points about its circumference. The work is indexed about its base by turning the holding flange and when passed under the surface grinder wheel, the shear is ground uniformly for each of the four stations to which the punch is set. The high spots at which the four sheared surfaces join are clearly indicated by the four radial lines across the face of the punch.

The Filing Process

Returning now to the actual work of finishing out the interior of a die opening, we may give a little consideration to the filing processes, hand

Fig 86.—Die maker's files

and machine, which are indispensable in the carrying out of the work of the die maker. The needle files and the die sinker's files on the bench plate in Fig. 86 are of the forms commonly required for die work and with the exception of a very few shapes, the two classes of files are similar in section, but differ in respect to the shank and therefore in the means of holding. The needle files are made with long slim shanks or round handles about 4 in. in length while the other type, known as die sinker's files, are provided with the usual pointed tang which is used commonly with a small handle that often is nothing more than a disk or wafer shaped affair (as seen in the half tone) which gives a light finger grip.

The two classes of files are shown in detail and designated by name in accordance with their shapes, in Figs. 87 and 88.

The machine filing process has eliminated a large share of hand filing on many classes of dies and greatly expedited the work of the die maker. With the bench filing machine he can watch the outlines of his work and

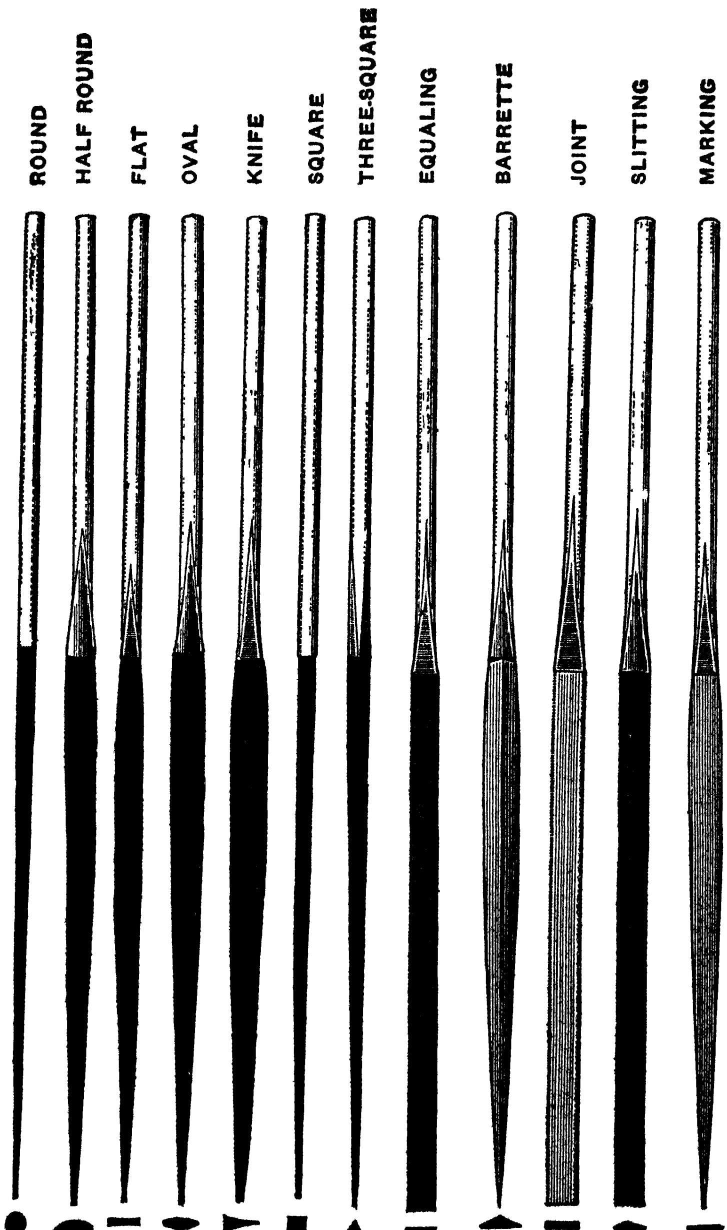


Fig 87 —Needle files (Disston)

with the file mechanically operated he can work the die along the table and remove the stock at the necessary places with little liability of overrunning the outline. And, with the table adjusted to the desired angle

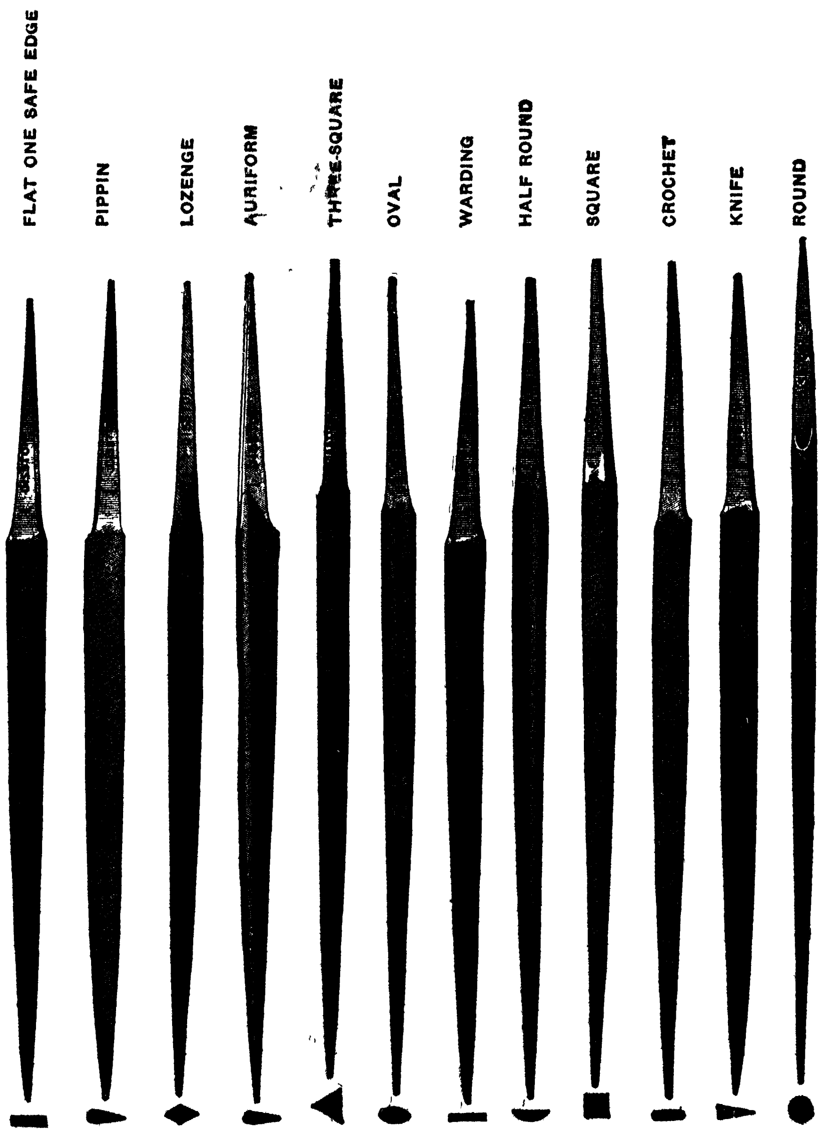


FIG. 88.—Die sinker's files (Disston).

for clearance, whether ½ degree or more, he can feel assured that he is holding to close uniformity to this clearance throughout the process, and that he is not likely to secure a bell-mouthed die in the operation.

A typical piece of work on the filing machine table is illustrated by Fig. 89. A group of files made specially for such machines is shown by Fig. 90. The shapes of these files with dimensions are given in Fig. 91.

FIG. 89.—Filing out a die opening.

Ordinarily they are made in four cuts, or degrees of coarseness. These are designated as Cuts Nos. 1, 2, 3, and 4. The exact size of the teeth for these respective cuts is given in the engraving, Fig. 92.

FIG. 90.—Files used in filing machine.

DIE MAKER'S SQUARES

The die maker has constant use for squares of various kinds in all of his work and particularly in filing out blanking dies and openings of similar character in other tools. The sketch, Fig. 93, gives the principal dimensions of a very handy square which is designed for fairly small work but which may be made to proportions to suit any class of work.

FIG. 91.—Bench filing machine files (Disston).

Its special feature is the hole beneath the blade, enabling one to see what sort of contact is made between the blade and the work inside a hole or slot in a die. As the amount of clearance used in different shops varies,

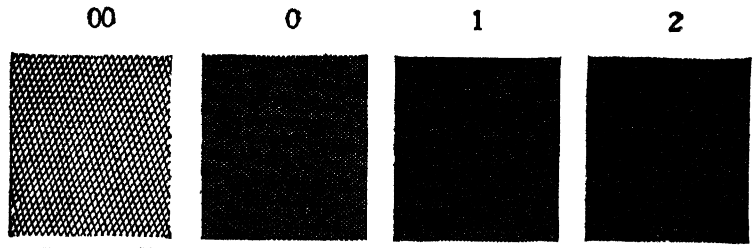


FIG. 92.—Nos. 00, 0, 1, and 2 cuts for machine files (exact size of cut).

the blade is adjustable. The base is made in two parts, so that the sides of the slot holding the blade can be ground parallel. In this way, a fit can be made that will be tight enough to hold the blade in place. While this blade is put in with a rivet, a tapered screw or some other means can be used that will fasten the blade securely and still be easily loosened when it needs adjusting.

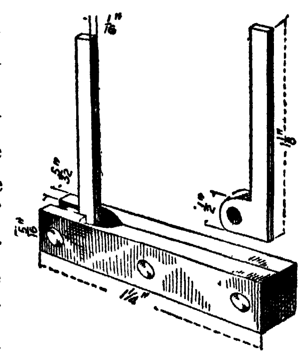


FIG. 93.—Die maker's adjustable square.

A square with this improvement of a screw at the side of the stock for securing the blade in fixed position is shown in Fig. 94. The square referred to is at the left of the group of three in this photograph. The one in the center is the conventional fixed blade tool and the one at the right is a square with blade secured by the knurled nut at the front of the stock. All three squares are very useful parts of the die maker's tool equipment.

GRINDING OUT DIES

Reference has been made to the possibility of finishing various shapes of dies by grinding out after hardening, and a few views are here shown where the grinding wheel is employed for such operations. Naturally an internal process of the kind mentioned is most readily performed with dies having circular openings, as with round blanking dies, and piercing dies of large enough opening to admit the wheel. But there are numerous instances, also, where the die opening terminates in a rounded end or a round corner or where an arc is formed along the main portion of the contour all of which allow a wheel to be employed to advantage if the size will permit a wheel to be used at all. Then, too, the straight lines connecting circular portions sometimes allow a grinding wheel to be

entered to finish these edges with the work stationary just as the circular parts are ground out by rotating the machine spindle.

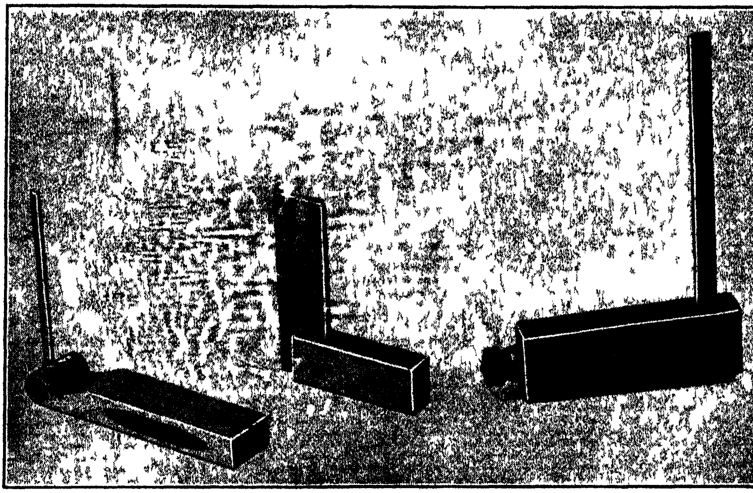


FIG 94 —Die maker's squares

FIG 95 —Finishing die opening with traverse spindle grinder.

In Fig. 95, a die is shown set up on the bench lathe face plate for the finishing of the round end of the die opening by the traverse spindle grinder. The die is, of course, located by indicating before securing to

the face plate and the work of sizing the portion referred to is then an easy process. The spindle with the wheel is set around to the necessary angle

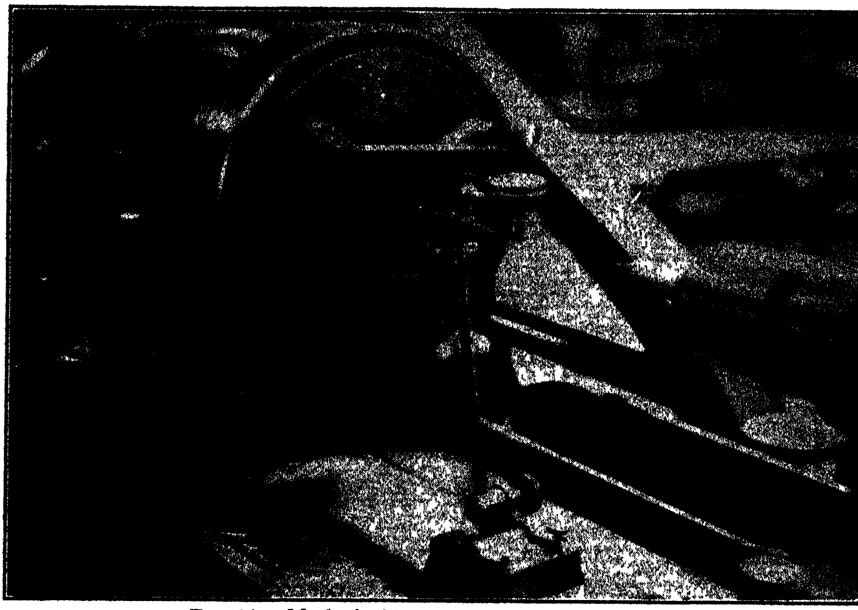


FIG. 96.—Method of indicating die before grinding.

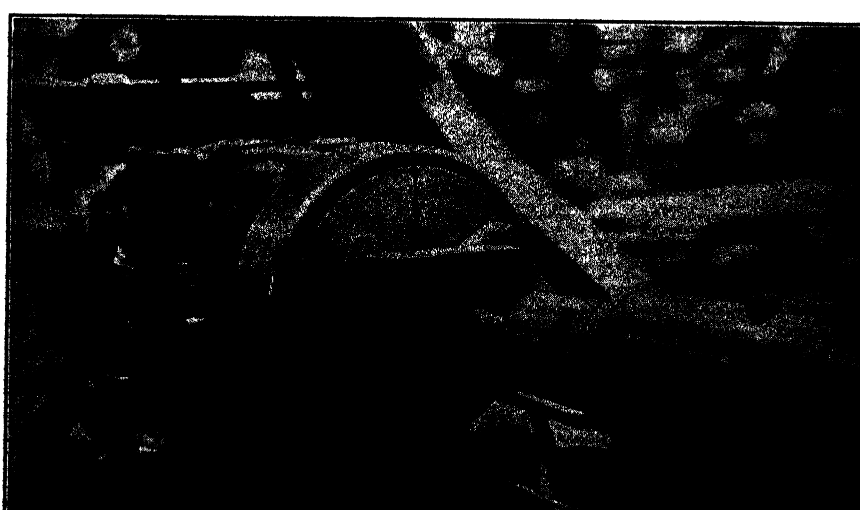


FIG. 97.—Grinding out the die.

by the compound rest to provide for the degree of clearance desired inside the die.

The operations illustrated by Figs. 96 and 97 consist of indicating the die in the chuck jaws of the internal grinder and then grinding out the piercing opening. The chuck jaws are faced true with the wheel and owing to the shape of the die there is no difficulty in holding the work satisfactorily in this manner. If necessary it would be an easy matter to secure the die to a face plate and follow the same process of indicating and grinding.

While the operations illustrated are the grinding of the circular piercing opening, the same operation may be performed on the circular enlargement at the center of the blanking die proper. The method of indicating would be the same and the wheel could be applied in exactly the same manner as for the plain cylindrical hole.

Operations on Punches

The machining and finishing of punches, consisting as it does of the working of external surfaces, is generally speaking a simpler problem than

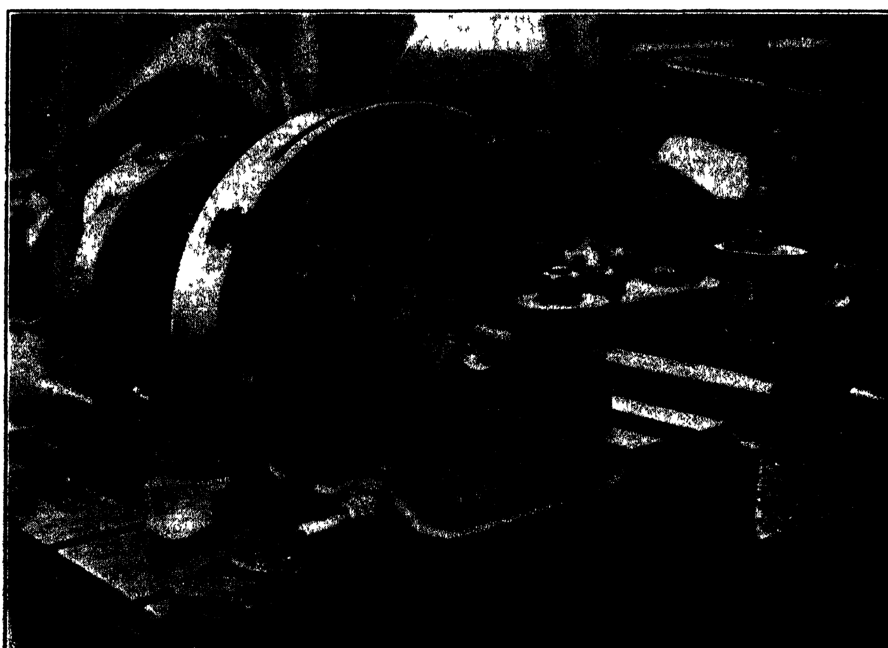


Fig. 98.—Making a punch in the lathe.

the making of dies, just as the finishing of the outside surface of any part is usually more easily accomplished than are the corresponding operations necessary to the completion of an internal piece of work. Plain cylindrical punches and others of regular section are, of course, readily machined and there are various other forms which, although apparently difficult to

produce when first considered, yet admit of handling by the elementary processes of the lathe, or the milling machine.

Examine, for example, the punch shown on the lathe carriage in Fig. 98. This is for cutting off flat stock to produce the round end link shown in Fig. 99. It is obviously a lathe or a milling machine undertaking to shape the opposite sides of the punch to the concaved form required. In fact such punches are made in both machines mentioned, but in the case illustrated the lathe is being used for the purpose. The metal which this punch shears is rather heavy and there is considerable

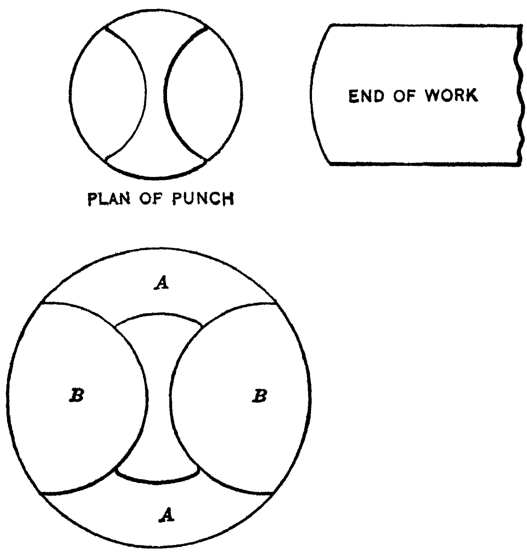


Fig. 99.—Punch and die for cutting off links with rounded ends.

clearance between punch and die so that the requirements as to accuracy of dimensions are not exacting, otherwise the punch blank could have been secured in a holder and the latter mounted on the lathe face plate for assuring a closer adjustment in setting for the two cuts to be taken on the opposite sides of the work.

In this instance the punch is shown gripped in the four-jaw chuck and offset from center the right distance for the turning out of the side to the necessary arc for rounding the cut-off link properly. Upon completion of the first side the chuck jaws are set over to throw the work the same distance the other way from the center for the boring out of the second concave form.

The die is seen at the front of the carriage. A die of this form, if solid, requires considerable time in the working out of the opening. If made in sectional form as in Fig. 99 the parts are turned out without difficulty,

the ends *AA* being bored as readily as a ring, and the side pieces *BB* turned and let into their places after which the outside portions are turned to match the diameter of the die as a whole.

A milling machine operation on a punch of crescent form is shown by Fig. 100. Here the work is seen set up on the face plate of the dividing head and the interior cut is under way. The outer surface has already been milled down closely to the outline scribed on the punch face and the inner cut will be similarly brought close to dimensions before the punch

Fig. 100.—Milling a crescent shaped punch.

is removed from the machine. The cutter is held in the spindle of the vertical milling attachment which is here swung to horizontal position, and the work is fed past the cutting teeth by rotation of the dividing head crank.

Larger Die Work

A method of machining a large set of dies is shown by Figs. 101 and 102. These dies are similar to certain sets illustrated in other sections of this book. They are of elliptical form and have a long diameter of about 18 in. The parts being machined in the lathe are of cast iron and these castings when finished are fitted with tool steel cutting rings which are shrunk or pressed into place according to whether they are fitted to the male or female die.

The point brought out by the illustrations is the method of locating on the face plate of the lathe by means of a parallel along which the work may be adjusted for position for the boring operations at opposite ends.

In Fig. 101 the die is represented in the operation of boring of the circular portion at the right of the center. For boring out the ends to larger

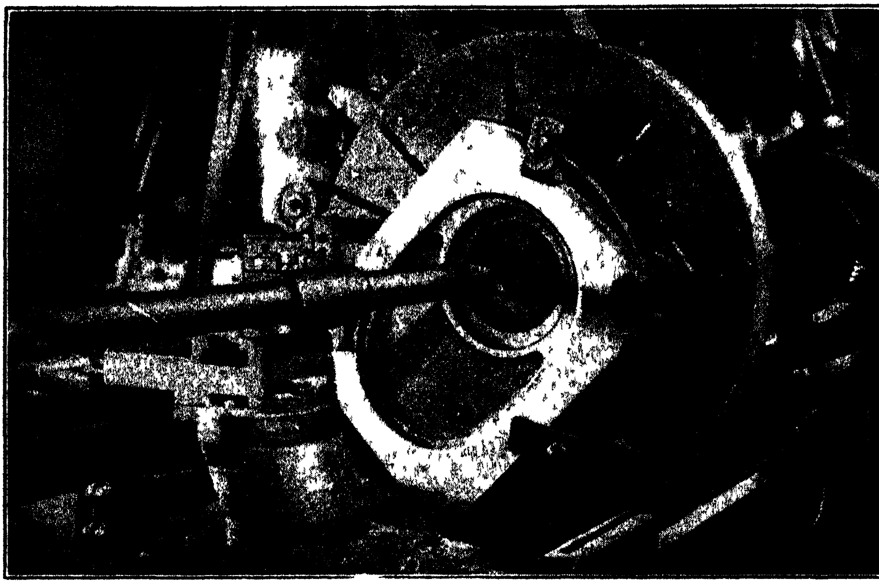


FIG. 101.—Making large dies.

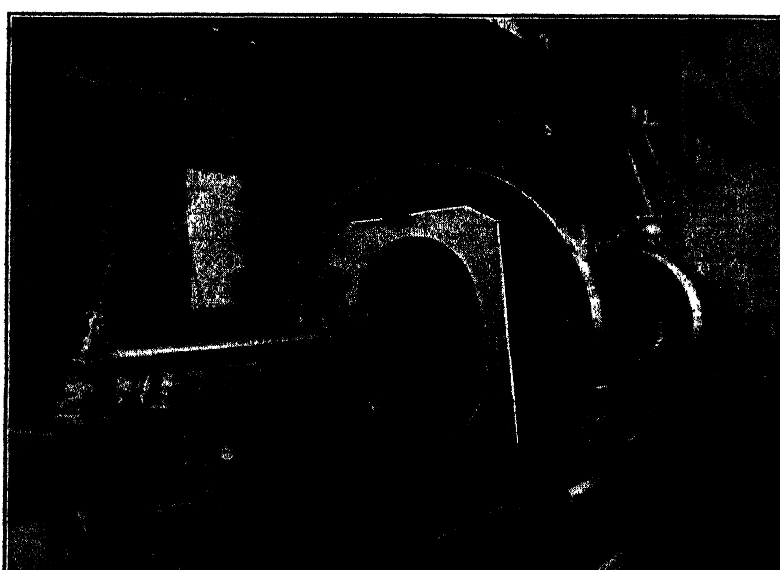


FIG. 102.—Boring out large die.

radius the work is moved along the parallel and reclamped at the right distance from the center to give the position for sweeping out the metal

at the end of the cored chamber For the opposite end of same radius the work is simply reset at the same distance from the other side of the center. The turning out of the still larger curves at the sides is accomplished as with the die member seen in Fig. 102, where the curve is swept out to join the arcs of shorter radius already finished.

Elliptical attachments for the lathe have been used for such work with success but they are not always available when special work comes along that has to be put through the shop in the least possible amount of time

CHAPTER XXIII

LOCATING HOLES ACCURATELY IN DIE WORK

The problem of locating holes in dies with the degree of accuracy desired is sometimes a difficult one, particularly where no special means in the way of a vernier equipped drilling machine or other tool of similar purpose is available. The small holes often required in piercing dies and in progressive piercing and blanking tools are generally more difficult of location if extreme accuracy is essential, than where holes of fair diameter are to be bored. For the small dimensions of the holes (and often of the die itself) may render the usual type of button unavailable for the purpose. Owing to the fact that the button holding screw cannot be made smaller than a certain minimum it may be larger than the hole to be bored, and even though the die is to be bushed so that a larger hole is permissible, the close center distance between holes may make it impracticable to button up the work in the manner followed with similar problems where there is more space between centers.

Aside from the necessity for many such holes in connection with piercing dies, there are some shops where it is customary to outline all blanking dies by means of small holes drilled at the corners, and at the ends of lugs and projections. These holes then form the limiting points to which all outlines in the die must be carried. They must be correctly positioned or the die will be inaccurate. They are usually of necessity quite small in diameter for often they are used for the additional purpose of leaving a small fillet in the die corners to produce a similarly small rounded corner on the corresponding part of the blank. Where a perfectly square corner on the work is not necessary this practice undoubtedly results in a better appearing blank and a stronger corner in the die. Under certain conditions, as stated above, it may add to the difficulties of making the die in the first place, but under other circumstances where holes are not too closely spaced and where suitable toolroom equipment is in use, the practice referred to may be of real aid to the die maker, who thus establishes at the outset all limiting points in the work to which all contour elements of the die must be held.

An illustration of a blank of this kind is presented in Fig. 103. At *A* is shown the blank with the radius of each corner and fillet specified. The layout of the holes to be first drilled in the die block is given at *B*. The outline of the die opening to be worked out after the holes have been drilled is indicated by the dotted lines.

The centers of the holes may be laid out by vernier height gage as shown in the previous chapter, with the die block clamped to an angle plate on the surface plate and the centers at the intersecting points of the scribed lines can be marked by a center punch and then drilled, or indicated on the face plate of the lathe and drilled in the machine. Or if space is sufficient the button method may be employed as in Fig. 104 and each hole indicated as shown and bored to exact location and size.

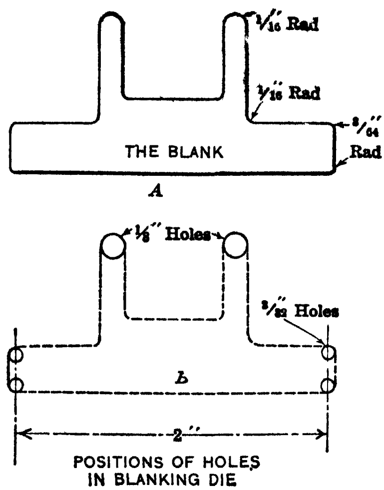


Fig. 103.—A blank and the location of limiting holes in the die.

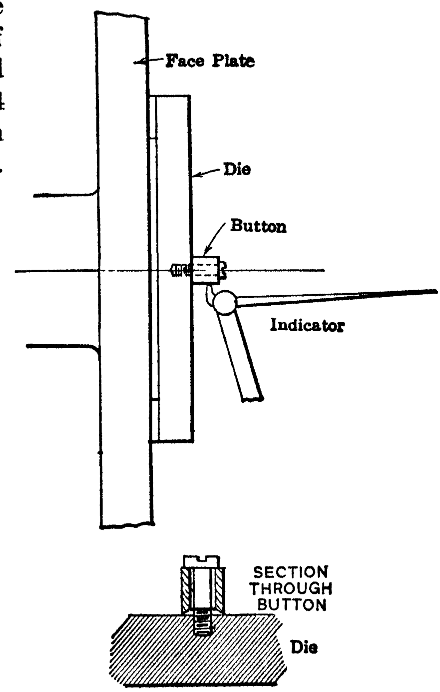


Fig. 104.—Application of the locating button and test indicator.

The buttons are, of course, set in position on the die by measuring across with micrometers or other precision tools.

Application to Progressive Dies

A good illustration of the principles involved in the making of a progressive die with several small holes therein can be gathered by following the different stages in connection with the tools for a clock part shown in Fig. 105.

From this sketch it will be seen that a tolerance of only 0.0005 in. either way is allowed for the center distances of all three holes. The circular rack *A* is rough blanked in the same die, sufficient stock being left for a finish shaving operation in another die.

The layout of the first die is given in Fig. 106. The blank, which is No. 19 gage (0.0437 in.) cold rolled steel, does not have to be held to close

limits, with the exception of the circular rack part. As this is finished in a later operation, the spacing of the three holes with sufficient accuracy comprises the real problem in this case.

The die opening A, Fig. 106, is worked out to a model and the $\frac{7}{16}$-in. holes B, C are bored part way through the die blank, the clearance holes being large enough for the full passage of slugs.

Two pieces of drill rod $\frac{7}{16}$ in. in diameter by $\frac{7}{16}$ in. long are next driven into these holes, and two $\frac{1}{8}$-in. holes are drilled and reamed halfway into the die blank and the drill-rod plugs, as at F. The plugs are next removed, and the die blank, with the finished die opening A, is hardened. After hardening, this die opening is honed and retouched to fit the model.

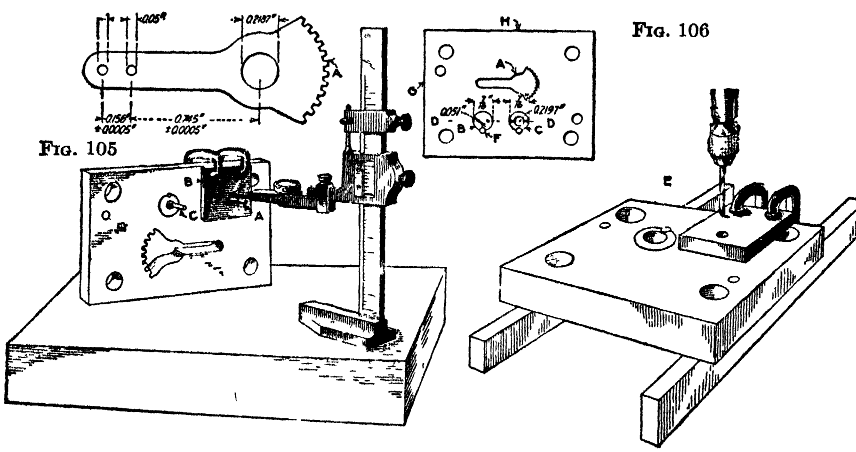


Fig. 105

Fig. 106

Fig. 107

Figs. 105–107.—Locating small holes accurately in dies.

The drill-rod plugs, together with $\frac{1}{8}$-in. dowel pins in holes F, are driven in, and the die blank is ground parallel on both faces. Also, the edges G and H are ground square, the edge H being parallel to the center line of the three holes. Grinding the edges G and H facilitates locating the button and the drill plate while the die blank is resting on those edges on the surface plate, as will be shown later.

Next the plug in the hole C is drilled and tapped for the button screw, and the button is set to the correct location by the usual method, using an indicator in the height gage and taking the necessary measurements from points of the finished die opening. The button thus secured is trued up, and the 0.2197-in. hole is bored out in the lathe. For the two 0.051-in. diameter holes the following method is employed: A piece of $\frac{3}{16}$-in. flat cold rolled steel is drilled so that a 0.051-in. rod is a good sliding fit in the hole, after which the cold rolled steel plate is cyanided.

Work on the Insert

Fig. 107 shows the successive steps in locating and drilling the two 0.051-in. holes in the inserted drill-rod plug in the die blank. With a 0.051-in. plug *A*, Fig. 107, in the drilled hole of the cyanided plate *B*, and a plug *C*, consisting of two diameters—namely, 0.2197 in. and 0.051 in.—concentric with each other (a good fit in the previously bored hole of the die), locating the plug *A* correctly for one of the small holes is but a matter of measuring with micrometers and the height gage from plug to plug, testing with the height gage as shown.

After the plug *A* with the plate *B* has been tapped into place, the plug *A* is removed and the die blank, with the drill plate held securely with clamps, is taken to a drilling machine. At *E*, Fig. 107, is shown the die blank resting on parallels on the table of the drilling machine, preparatory to drilling the 0.051-in. hole. It might be said that the hole is first spotted through the drill plate with a 0.051-in. drill, then drilled right through with a drill a few thousandths less in diameter and finally reamed with a 0.051-in. twist drill, which has the corners rounded so as to produce a smooth hole. The drill plate is next removed and the remaining hole treated identically.

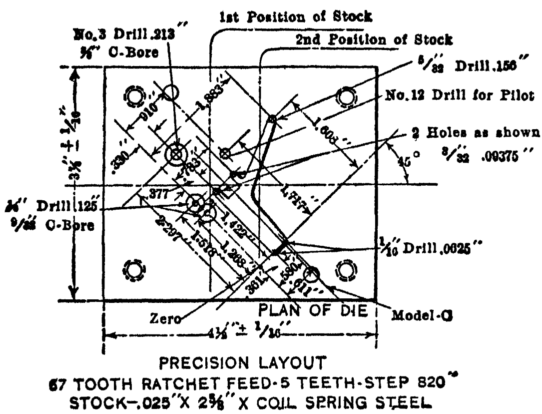
All three holes are now taper reamed from the back for clearance; both $\frac{7}{16}$-in. drill-rod plugs are removed from the die blank and hardened, after which they are again pressed back in their respective holes, the $\frac{1}{8}$-in. dowels lining them up to positions they occupied while being drilled and bored. A slight finishing cut is taken over the die face in the surface grinder, thus completing the die blank. The punch holder plate for this die is drilled by the same method; and the blanks, when they come from this punch and die, are well within the limits specified. In cases where one of these drill plates is to be used frequently, it is a good policy to make them out of hardened tool steel; a piece of ground tool steel stock does nicely for this purpose.

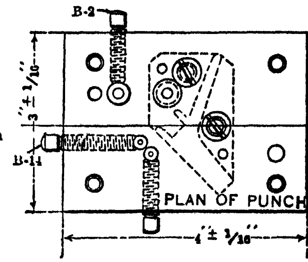
The method just described is a very valuable one in shops where the equipment is not of the best, but where the quality of work turned out is expected to be first class.

The Precision Layout

In some factories the drawing office supplies the die maker with a complete layout of the tools required so that the centers of all holes are given in thousandths of an inch from one starting point which once located forms the zero mark from which every hole is accurately spaced. The drawing in Fig. 108 shows a progressive piercing and blanking die for the blank in Fig. 109 with all holes located in reference to this zero point. This is a typical layout as made by the Smith Premier Typewriter Com-

pany for use in connection with the precision drilling machine made by them for use in their tool room. The same principle however can be adapted for service in tool rooms having a milling machine with vernier scales attached for the table and knee movements, although naturally the





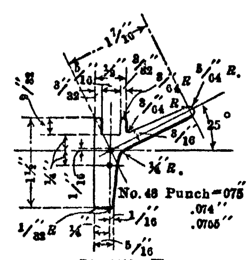


Fig. 109

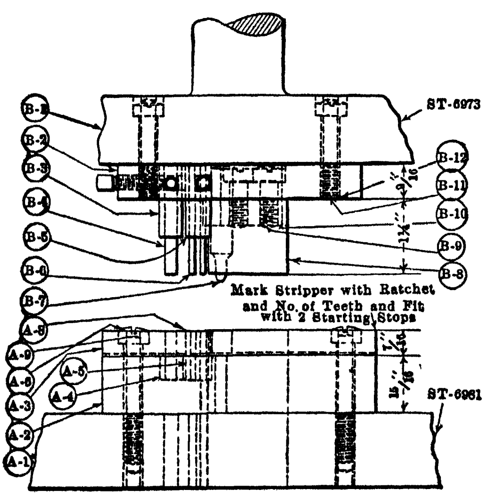


Fig. 108

.025" Spring Steel
2 per Mach.

B-14	1	¼"x 1⅛" Sq.Hd.	Set Screw
B-13	2	¼"x ⅝" Sq.Hd.	Set Screw
B-12	4	5/16"x 1½"Fil.Hd.	
B-11	2	3/16"x 1⅝"D.R.	Dowel
B-10	2	3/16"x 1"D.R.	Dowel
B-9	2	5/16"x ¾"Fil.Hd.	
B-8	1	1⅝"x 3"x 1⅝"T.S.	Punch
B-7	1	⅝"x 2"D.R.	Pilot
B-6	2	.075"x 1¼"D.R.	#48 Punch
B-5	2	9/32"x 1¼"D.R.	Bush
B-4	1	3/16"x 1¼"D.R.	Punch
B-3	1	⅝"x 1¼"D.R.	Bush
B-2	1	⅝"x 4"x 3"M.S.	Punch Plate
B-1	1	ST 6973	Stock
A-10	1	ST-6892	⅜" Guide Pin
A-9	1	ST-6895	15/16 " "
A-8	2	5/16"x 7/16"D.R.	Bush
A-7	2	¼"x 2¼"D.R.	Dowel
A-6	4	5/16"x 2"Fil.Hd.	
A-5	2	⅜"x 7/16"Drill Rd.	Bush
A-4	1	⅜"x 7/16"Drill Rd.	Bush
A-3	1	⅜"x 6"x 4"M.S.	Stripper
A-2	1	1"x 4"x 4¼"T.S.	Die
A-1	1	ST. 6961	Stock
No	Quan	Material	Remarks

Figs. 108–109.

special drilling machine noted has certain advantages for this peculiar class of work not to be expected of the general purpose tool room miller.

The precision drilling machine has a vertical spindle mounted in a slide with power mechanism for feeding the drill through the work. There is

a rigid drill support which guides the drill at the point of cutting and the work is held on a table which closely resembles in design and operation the table of a milling machine, as it is fitted to a saddle on a knee of the miller type and has therefore all of the movements of the miller table. The machine is built with extreme accuracy and its performances in the correct locating of holes in dies and similar tools are remarkable not only

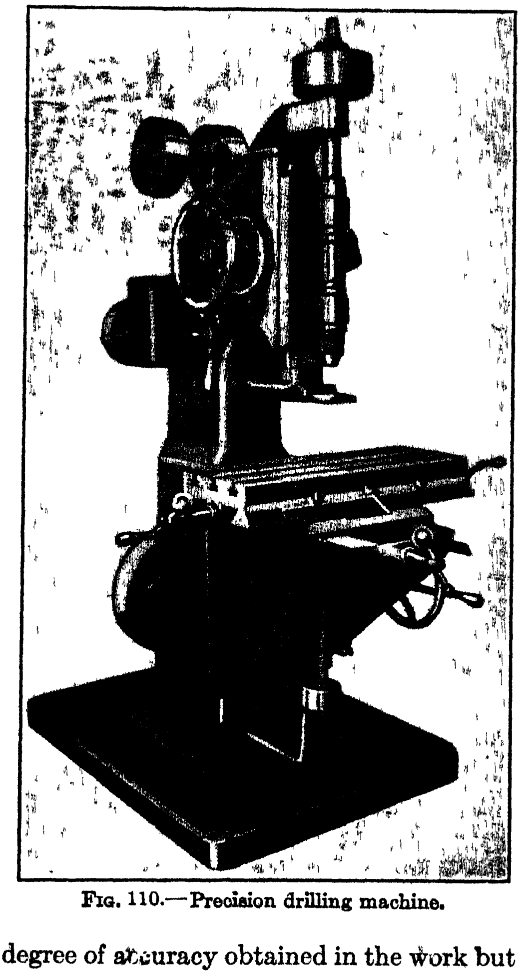


FIG. 110.—Precision drilling machine.

because of the degree of accuracy obtained in the work but also because of the rapidity with which it accomplishes its operations. The table and saddle are equipped with vernier scales. The drill support is equipped with a set of hardened and lapped bushings varying in diameter of hole from No. 54 drill size to $\frac{3}{4}$ in. Holes as large as 2 in. can be bored by means of an eccentric boring tool. A general view of this interesting precision tool is presented in Fig. 110.

How the Precision Layouts Are Used

The toolmaker in charge of this machine is assisted considerably on the job by the provision of the precision layout by the drafting room. The layout is made at the same time the tool is drawn up and gives, for the sake of clearness, merely the information needed to perform the precision drilling. Samples of these layouts are shown in Figs. 108, 111, and 112. The toolmaker clamps the work to the table and brings the work under the spindle so that the latter is directly over the zero point as indicated on the layout. The zero point may be scaled from the edge of the work, as is necessary in Figs. 108 and 111, or it may be at the corner of the block. When the drill spindle is over the zero point, as shown by

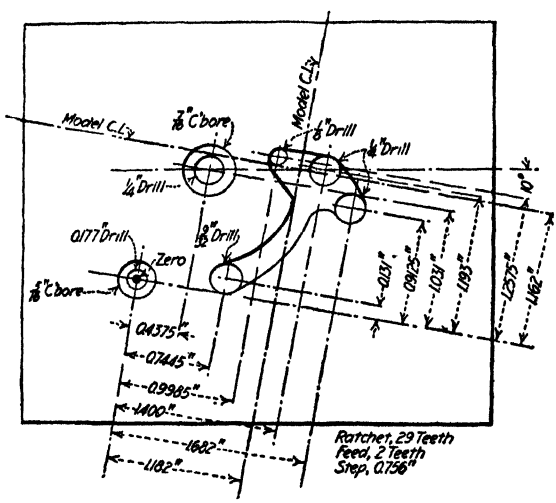


Fig. 111.—Layout for blanking die precision.

an indicator in the chuck, the scales on the table and spindle are set very carefully at zero. The holes on the layout are all located in thousandths from the zero point in two directions, thus enabling the toolmaker to complete the drilling without resetting the scales. The rest of the operation is simple, the toolmaker carefully moving the table until the scale readings correspond to the coördinates as given on the layout and then selecting the proper bushings, drill, and reamer to complete the hole. Care is taken to have the work close to the drill-support slide so that the point of the drill is steadied as it enters the work. To change the drills the drill is raised from the bushing, the slide unclamped and pushed back in the frame and the drill taken out.

The use of the scales permits the exact location of the work in relation to the drill spindle regardless of any backlash or wear in the lead screws. The drill support, which insures the drilling of the holes in the exact spot

required, is used only until the drill is started in the work. Then it is moved back and the hole drilled. This is done to reduce the wear in the bushings. The reaming is done through the bushings.

The precision drill has been used effectively in the laying out of dies and in the removing of stock from die blocks. It is equally effective in locating bushing holes in drill jigs. It has also been of great assistance in the making up of models prior to the starting of regular production.

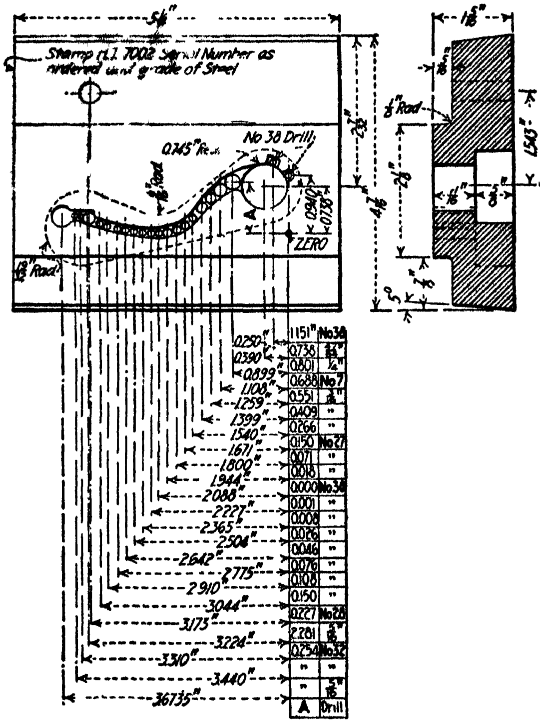


FIG. 112.—Precision layout for blanking die.

In Fig. 111 is shown a good example of the layout for a blanking die to be used in a press with automatic feed. The exact location for the holes for piercing punches and leaders in the die block is thus quickly provided. The layout in Fig. 111 is shown with the axes at an angle of 10 degrees with the side of the die block. This does not lengthen the operation on the precision drill as the stock can be clamped on a swivel table and turned to the required angle quickly. The work of preparing the layout, however, is considerably decreased as the axes are parallel to the center line of the part drawing and therefore the calculation of the coördinates is simplified by merely having the block turned at the required angle.

In Fig. 112 is shown an example of a die block with a large part of the stock removed on the precision drill. This die is subjected to severe service and requires frequent replacement. Consequently it is considered economical to provide a very complete precision layout giving ordinates and drill sizes so that the finishing time for the die would be materially reduced. The irregularity of the form of this die would make a difficult task of laying out for drilling by the die maker in a sensitive drilling machine. The irregularity of form would also increase the probability of error and the consequent spoiling of the die by the die maker. The precision drill, however, takes care of this job in a very simple fashion, and the work comes to the die maker in a manner that requires the minimum of stock removal.

. The use of the precision drill for Fig. 112 does away with the necessity for making accurate templets for laying out the curved edges of the die.

The Use of Master Plates

The master plate is a device well known to toolmakers engaged on high class work. It has numerous applications in various branches of tool work but is less frequently employed in connection with the making of dies and punches than with certain other lines of precision work, although there is no tool room branch where it can be used more effectively than in the construction of press tools.

There is perhaps a certain amount of misunderstanding in regard to the making of such plates that tends to prevent the extension of their uses to the full in connection with die construction as well as in some other directions. It has been found a more or less common belief in some classes of shops that the master plate is specifically a watch toolmaker's device and that it is limited by first cost and unnecessary refinement to the needs of the watch factory tool room and similar departments in other shops doing practically the same kind of work.

This belief, while a commendation of the superior qualities of the master plate, is unfortunate in so far as it may have delayed the adoption of this most convenient device in different tool rooms and for various grades of die work. The master plate is truly a tool of precision, assuming it is made with the degree of skill and care which it merits; but it has its legitimate uses in other places as well as in such tool rooms as turn out only the highest grade of precision work. And if toolmakers but stopped to realize that the purpose of the master plate is to make possible exact duplication of its own qualities of accuracy, whether that accuracy is of the highest or of only moderate degree, they would see many opportunities to employ it to advantage where now they only too frequently leave it entirely out of consideration so far as the greater part of their work is

concerned. This is true to an even greater extent with die-making than in general tool room practice.

Now a jig is a device for duplicating within the running limits of drills and reamers, the center distances established by its own guide bushings. If these distances are accurately determined in the construction of the jig, the parts that are drilled therein will be as close duplicates in respect to hole locations as the operation of the drills will permit. But if we are seeking for a perfectly true job of boring with holes as straight and round as possible, and if moreover we wish to secure the closest accuracy in the relative locations of two or more such holes, we will naturally resort to some form of face plate process where the work can be swung as in a lathe and where after the centers of the holes have been indicated with a test indicator the work can be drilled and then completed by rotating it on its own axis while a boring tool is applied until the hole is finished to the desired diameter.

The master plate is essentially a face plate appliance. It enables us to mount our work on the face plate and secure for each and every hole bored out the exact degree of precision in location that is represented by the master itself. A center distance established in the master plate is reproduced exactly in the work and if a duplicate job arises at any time it is bored out with the same degree of exactness as was obtained for former pieces.

In its application to press tools, it enables the die maker to bore punch plates and dies as precise duplicates of each other with the assurance that the center distances thus obtained will bring the tools into positive alinement when assembled. The replacement of either punch plate or die, or both, at any time is readily accomplished with the aid of the master plate and there will be no question as to the preservation of the original center distances in the newly made parts.

Whatever the qualities of the master plate as to accuracy, these are transferred to the work. If a set of dies is required of unusual degree of accuracy, the master plate will be found a most effective agent in the carrying out of their construction. If on the other hand there is no demand for precise location of hole centers, but replacement of the tools is a deciding factor, the master plate will prove fully as effective as in the other case.

Thus far we have considered the master plate as of service in the locating and boring of holes only. It is equally valuable as an aid to the correct working out of various regular and irregular die openings and punch forms on the lathe and in the milling machine.

Illustration of a Master Plate

As an illustration of a simple master plate and its application to a piece of die-making let us refer to Figs. 113, 114, and 115. The master

plate will be seen to be a plain block of steel in which a series of holes are accurately bored to suit certain center distances required in the die. In use the master plate is placed on the bench lathe face plate as in Fig. 645 where it fits snugly over a hardened and ground center plug A placed in the taper hole in the lathe spindle. The master plate B may be secured by light straps and screws as indicated or by other clamping means, but it is obvious that it must seat squarely against the perfectly true plate and be held there without being sprung or deflected.

The work, the die C, is secured by screws and dowels or if quite small may be soldered to the face of the master plate. With hole No. 1 of the master plate located over the center plug A, the work is in position for the boring of the hole 1′ in the die. When shifted to hole 2 the plate

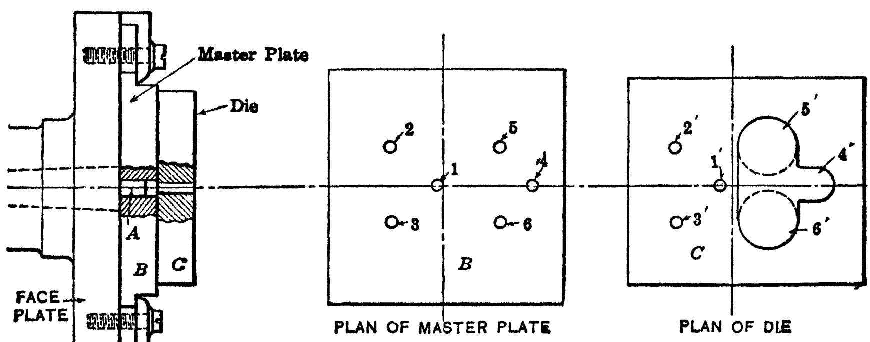


Fig. 113 Fig. 114 Fig. 115

Figs. 113–115.—The use of the master plate.

brings the die block into position for boring hole 2′ (Fig. 115) and so on until the work is completed.

In the illustration, the die has three holes (1′, 2′, 3′) for piercing and there are three locations (4, 5, and 6) for setting the die for the boring out of the enlarged circles 4′, 5′, and 6′, for the blanking opening. These larger holes are bored with the same accuracy and convenience as the small piercing holes, and after they are completed, the plate and work may be transferred directly to a miller for finishing out the die opening, to the full lines of the sketch.

The punch plate may be handled on the same master plate for the boring of the holes for the piercing punches and the blanking punch can be milled up to form by mounting the master on the dividing head face plate and rotating it to swing the work past the milling cutter for the rounding of the three lobe ends. Held in the same place with the work revolved to horizontal or vertical position the straight surfaces of the punch can be milled to desired dimensions.

A blanking die with most irregular opening can usually be worked out from a master plate without difficulty by providing a locating hole in the plate for each arc and curve in the die opening.

With a master plate once made, a complete set of dies, piercing, blanking, shaving, etc., can all be made to uniform centers for accuracy of spacing by handling each in turn on the same master.

Some master plates for such operations are illustrated by Fig. 116. The dies for which they are made are used continuously and frequent replacement is necessary. The plates give all the center locations for the

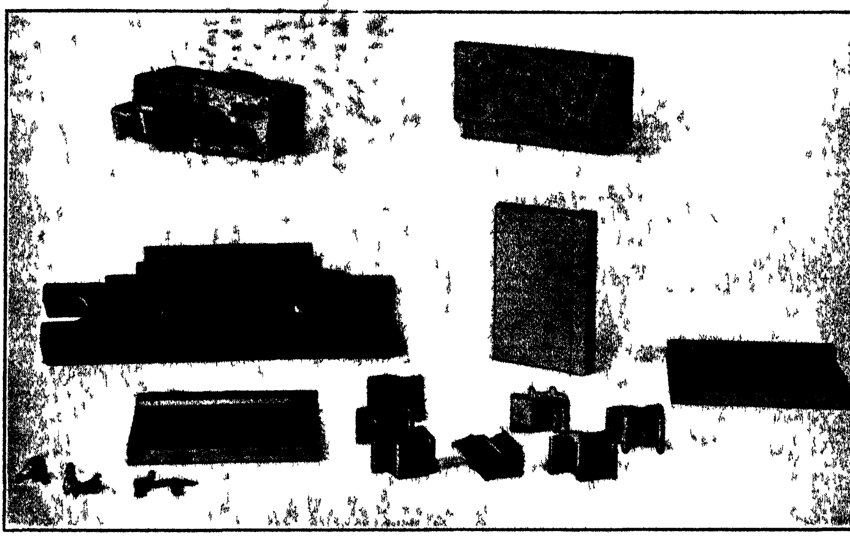


FIG 116.—Master plates for die work.

piercing holes and for the various curves and arcs in the blanking die contour.

The holes in master plates themselves are located originally by the most accurate methods that the toolmaker can bring to bear upon the work. The button method is one of the most commonly adopted and if properly followed it will produce results well within the limits of any requirements likely to be demanded of any plate in usual high-grade service. An unusual degree of care is necessary in indicating the buttons and in boring the individual holes in the master plate They are generally drilled close to boring size, bored to leave a slight scraping reamer cut and then lapped by hand to perfect fit for a plug gage. It will be understood that the plate itself must be as nearly a plane surface as possible before it is put on the face plate. It is usually the case that the tool steel plate is ground and lapped on the faces before boring operations are started.

CHAPTER XXIV

MAKING A SET OF SHAVING DIES

The illustrations in this chapter represent the important steps in the construction of a set of shaving dies for a toothed blank $\frac{9}{16}$ in. in diameter by 0.050 in. thick. The blank is made from half-hard steel and has nine teeth 0.0887 in. deep. The amount left in blanking for finishing in the shaving dies is 0.003 on a side or a total allowance of 0.006 in.

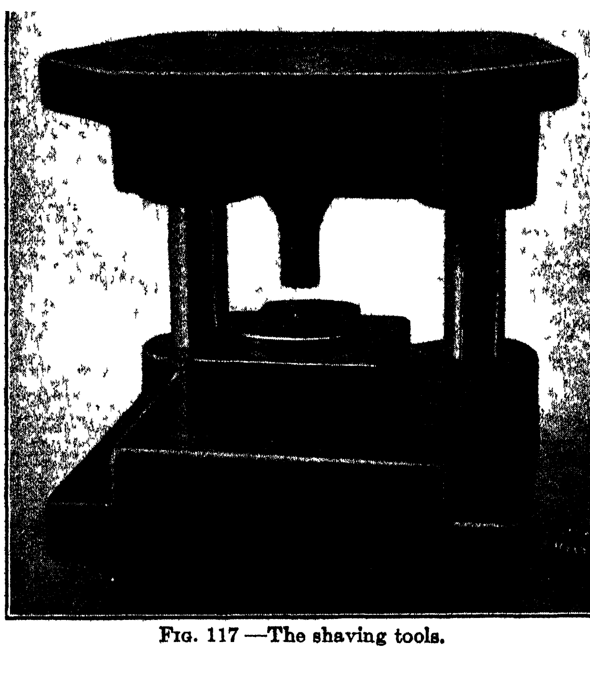


FIG. 117.—The shaving tools.

The dies are of the pillar type and are shown in Figs. 117 and 118. All parts are seen in the group photograph, Fig. 119, including even such details as dowels and screws. The die proper is 3 in. square by $\frac{15}{16}$ in. thick. The die opening is made straight down without clearance for a depth of $\frac{1}{4}$ in., below which it is tapered out for work clearance at an angle of 1 degree on a side. The die can thus be ground down to a depth of $\frac{1}{4}$ in. before its size becomes affected by the clearance angle.

Working Out the Die Opening

There are different ways of getting out the stock from a die opening such as is required here. After the hole is drilled at the center to remove as much material as later operations will justify, the area between the teeth may be drilled out by two or three different sized drills to leave but a narrow wall between drill holes and a close margin between holes and die contour. Or, if the die opening roughed out is sufficiently large in diameter, a slotting tool may be applied to the work with the die indexed in the dividing head of the miller and the rough form of the teeth outlined

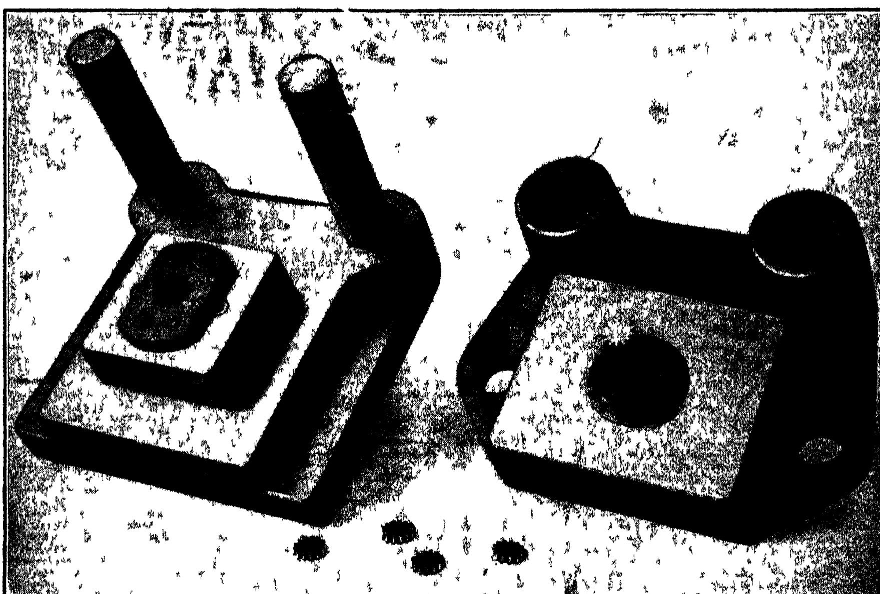


Fig. 118 —Punch head removed from die.

by the shape of the slotting cutter. In any event enough stock must be left to assure the toothed contour being finished to exact requirements, and with a small toothed die like this the hand file and bench filing machine are relied upon to a large extent to assist in getting the tooth form roughed down and then with a combination of file and broach the opening is finished.

The die is shown on the filing machine in Fig. 120. The half tone, Fig. 121, shows the broaches used in working the die to shape. There are two of these broaches, both shown to the right of the die. The punch, unfinished, is seen at the left-hand side with the roughed out nest in front. The formed milling cutters at the right are the ones used for milling the broach teeth.

The sizes of the broaches differ but a few thousandths for only a slight amount of stock is removed by each broach. Even this is taken out piece-

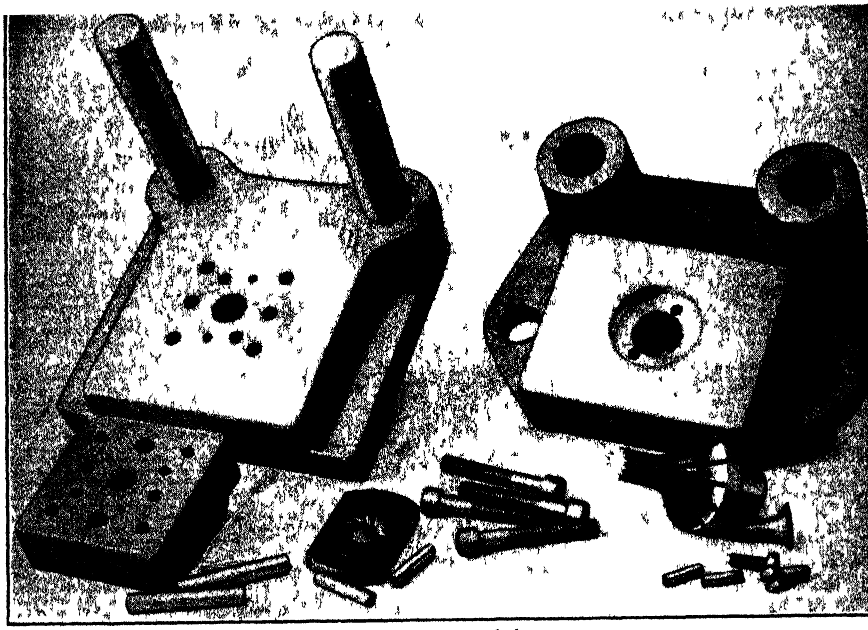


FIG 119 — Punch and die parts

meal; that is the broach is forced into the die opening say $\frac{1}{64}$ in. deep, then removed and the filing machine resorted to to work out the depth of the

FIG. 120.—The die on the bench filing machine.

die toward the minute shoulder left by the cutting end of the broach. Then the broach is forced in again, this time another sixty-fourth and the

filing process repeated. After the first broach has been passed through the die by repeated stages, aided by the working out of the superfluous metal by the file, the second broach, a couple of thousandths larger, is

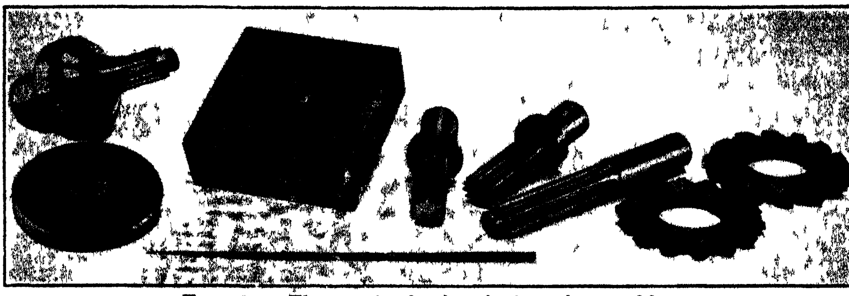


FIG. 121.—The punch, the die, the broaches, and lap

started through in similar fashion. The operation of forcing the broach into the die under a hand-screw press is represented by Fig. 122. For the purpose the broach is mounted in a punch head as seen here, and the die

FIG. 122.—Method of broaching out the die.

is placed upon the base of a pillar set. The tools are thus properly alined and the passing through of the broach is merely a case of alternating between the operations of forcing the broach in the slight distance referred to at each step and filing out to correspond to the advance of the broaching process.

The straight shank tool at the side of the broaches in Fig. 122 is a lap which is used at a later stage in the finishing of the die. That is, after the die has been sized by means of the broaches and filed for the slight clearance below the straight portion which is $\frac{1}{4}$ in. deep, the die is drilled and tapped in the four corners for four $\frac{5}{16}$-in. fillister head screws for holding it to the die base and also drilled for two $\frac{5}{16}$-in. dowels; it is further drilled for the screws and dowels for holding the nest and then it is hardened and is ready for lapping as in Fig. 123.

The lapping is done under a sensitive drill spindle, with the lap held in the drill chuck as illustrated. Fine emery and oil being applied to the

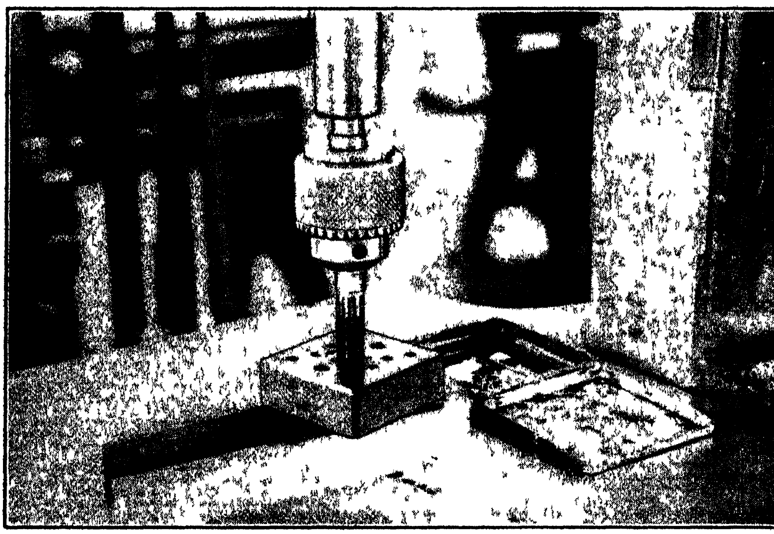


FIG. 123 —Lapping the die opening.

teeth milled along the lap surface, the spindle, while standing without rotation, is moved up and down by the operating lever to lap out the entire toothed opening in the die and bring it dead to size with all points in the working opening perfectly smooth and the working depth of the die perfectly straight.

Operations on the Punch

The punch is turned up in the bench lathe from a length of tool steel. It is left with a large body which is swept out in a liberal curve to the working diameter of the punch which is left straight for a length of 1 in. The diameter of the body is about $1\frac{1}{4}$ in. and back of the enlarged portion is a hub or extension which is $\frac{3}{4}$ in. diameter. This hub and the body or enlarged shoulder are left a little over-size but are afterward finished to fit closely in recessed seats bored out in the face of the punch holder or head as shown in the detail engraving, Fig. 119. The outer end of the punch,

that is, the working end, is left ¼ in. long (Fig. 121) and is turned down to a size equal to the diameter of the roots of the teeth so that it may serve as a pilot in a later operation where it is sized by being passed into the die.

The punch teeth are then milled as in Fig. 124, with the work held on the dividing head centers of the milling machine. The formed gear cutters for this operation are seen at the extreme right in Fig. 121. The teeth are cut with great care to produce smooth results and accuracy of size and tooth forms. The punch is then secured in a holder and sheared into the die with the projecting pilot acting as a guide. The tools are set

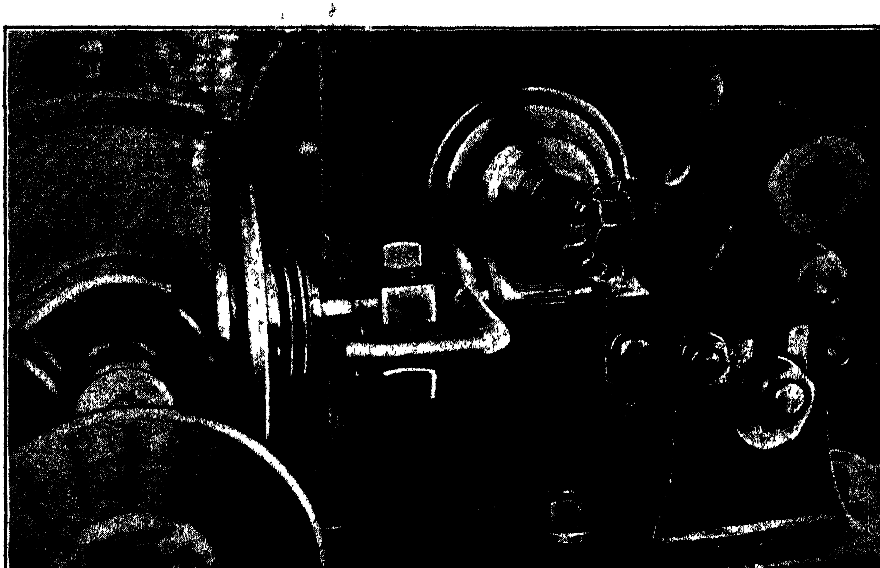


Fig. 124 —Milling the punch.

up for this operation as in Fig. 125 which illustrates the method of clamping the die on its base after the punch head has been slid down to enter the punch pilot into the die opening. With the tools thus arranged, they are transferred to the hand-screw press and the punch sheared in as explained.

The pilot of the punch is now cut off by setting up the punch in the bench lathe and the holes are drilled in its flange or shoulder for two fillister head screws and two dowels. The screw holes are tapped and the punch is then hardened. After this it is placed in the bench lathe for the grinding of the shoulder and shank. This shank or hub when first turned is left a few thousandths over-size and to finish it to dimensions the punch is placed in a bushing in the chuck which is bored out to receive the cutting end of the punch. While held in the bushing in this manner, the punch is tested for running truth of the hub by an indicator placed

as in Fig. 126 and then ground to diameter by a wheel on the traverse spindle grinder, Fig. 127. The punch can now be seated in its holder or

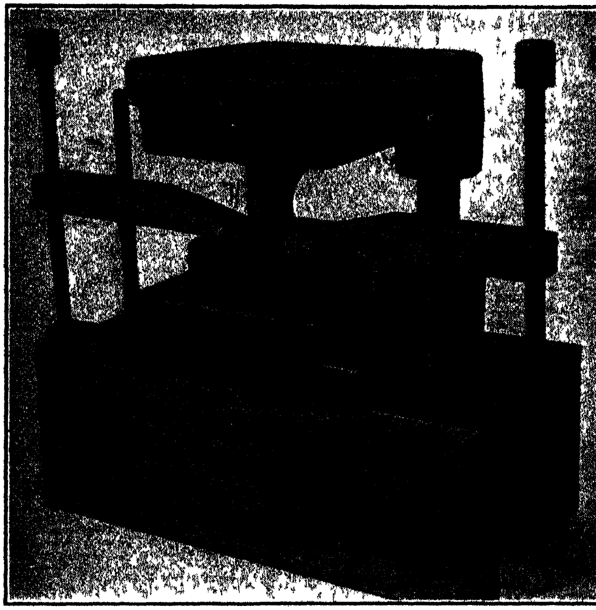


FIG. 125.—Clamping the die in line with the punch for drilling holes in base.

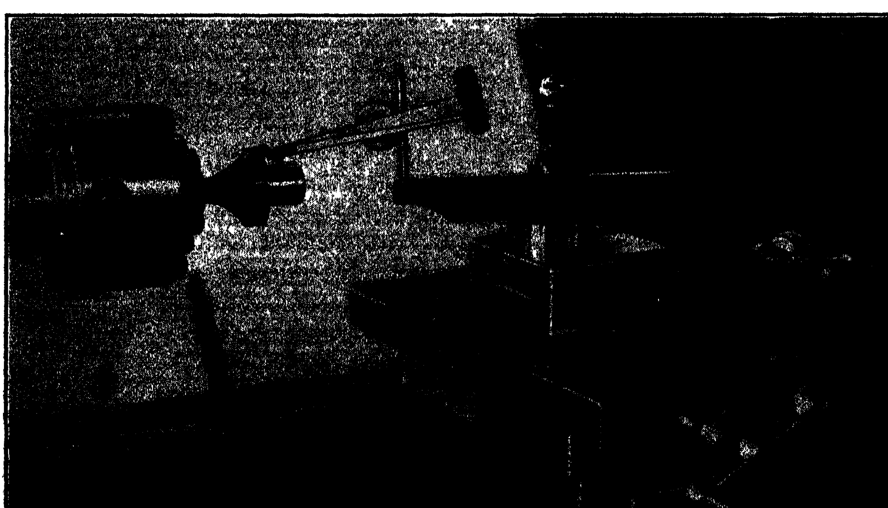


FIG. 126.—Indicating the punch in the bench lathe.

head as in Fig. 128 and used as a jig for the drilling of the holder for the screw holes and the holes for the dowel pins.

Up to this point the die has not been secured to its base or shoe. The operation of locating it in line with the punch for the drilling of the screw

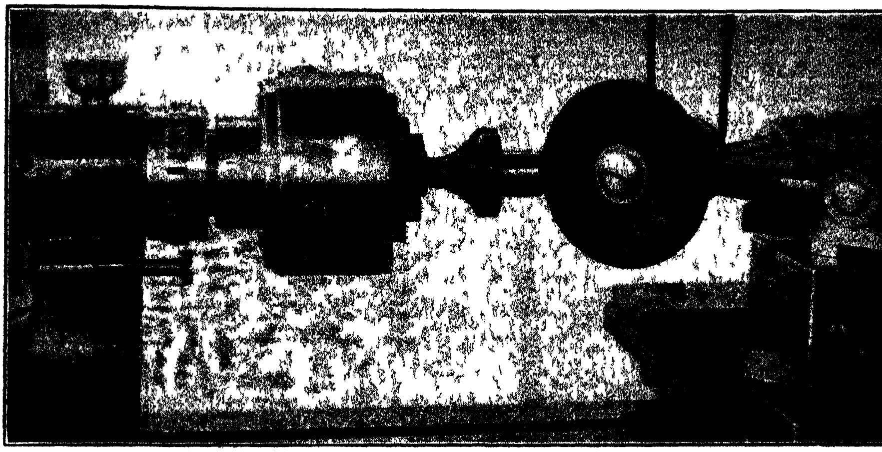


Fig 127 —Grinding the punch shank.

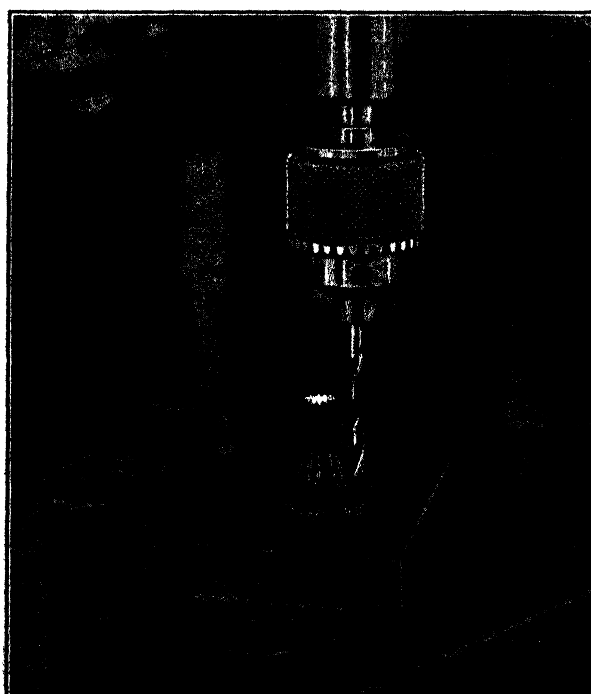


Fig. 128.—Drilling the punch holder for screws and dowels.

and dowel holes in the base is accomplished as shown again by Fig. 125. The punch head is placed over the guide posts or pillars in the die base and

the punch entered into the loose die proper to aline it properly with the punch. The clamps are applied as shown to hold the die temporarily for the drilling operation and the punch head slipped up and off the guide pins. This leaves the die clear for the drilling of the four screw holes and two dowel pin holes in the base. Following the drilling, the clamps are removed, the screws and dowels are placed in position and the die is thus fixed in position on its base.

Making the Nest

The nest is originally a round disk of steel faced down to $\frac{1}{4}$ in. thick and drilled through the center to a size suitable for filing and broaching out to the shape and dimensions of the toothed blank which it will be required to

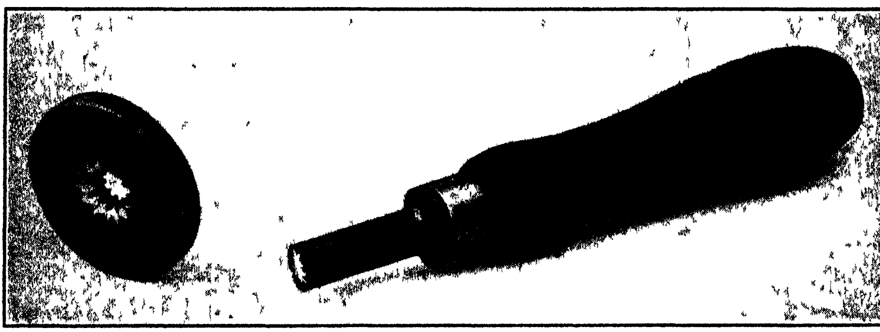


Fig 129 —The nest and the hand tool.

hold on the die when in service. A hand broach is used on this thin nest in addition to the regular broaches already described. This broach is shown at the side of the stripper blank in Fig. 129. It is used in conjunction with the filing process and in connection with the blanking punch which is made use of as in Fig. 130 for sizing the nest opening. The nest is in fact set up in the regular blanking dies for the toothed wheel which it is designed to hold, and the blanking punch is applied as a broach to assist in the working of the opening to desired size and form. With the punch entered slightly, say to $\frac{1}{64}$ in. depth, a guide mark is formed in the nest for enabling the opening to be scraped and worked out by means of the file and by the hand tool in Fig. 129.

After the nest opening is sized properly, the bottom side is recessed and the top is counter-sunk or chamfered to leave a beveled surface for easy placing of the work in the nest. The clearance underside is cut in sufficiently to leave an actual full size nesting opening about two-thirds as deep as the thickness of the stock. The recessed portion at the bottom forms a clearance space for chips.

When the nest opening has been completed, the sides of the disk are milled away to leave a form similar to that shown in Fig. 118 and the holes

FIG. 130.—Broaching out the nest.

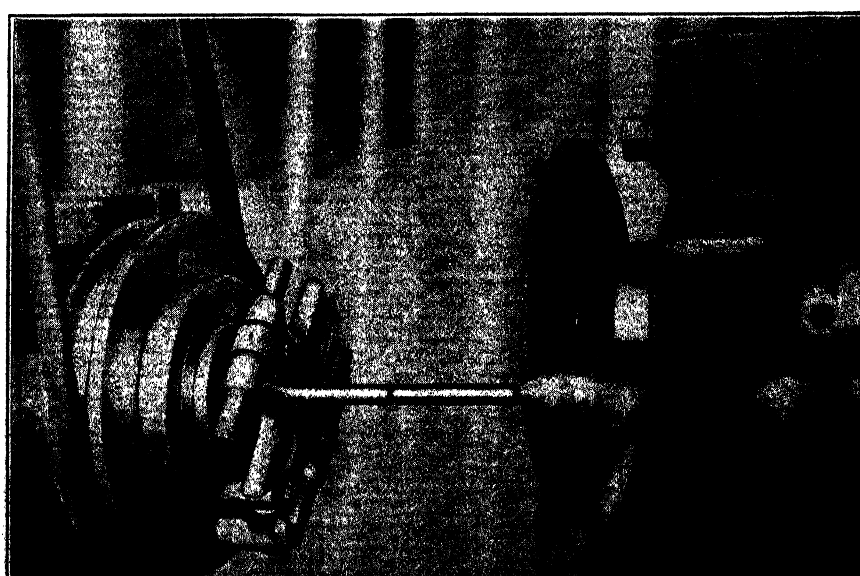


FIG. 131.—Grinding dowel pins.

are drilled for screws and dowel pins. This is done in alinement with the die holes by using the die as a jig.

Finishing Dowel Pins

A word may be added here in regard to the finishing of the various dowel pins used in these tools. The practice in the shop making these dies is to take a length of steel slightly larger than the required size of dowel and long enough for two pins to be made from one piece. The stock is turned on centers to say 0.008 in. above size and then necked in the middle to a depth of $\frac{1}{16}$ in., then it is hardened. After this it is placed on dead centers in the grinding machine as shown by Fig. 131 and the

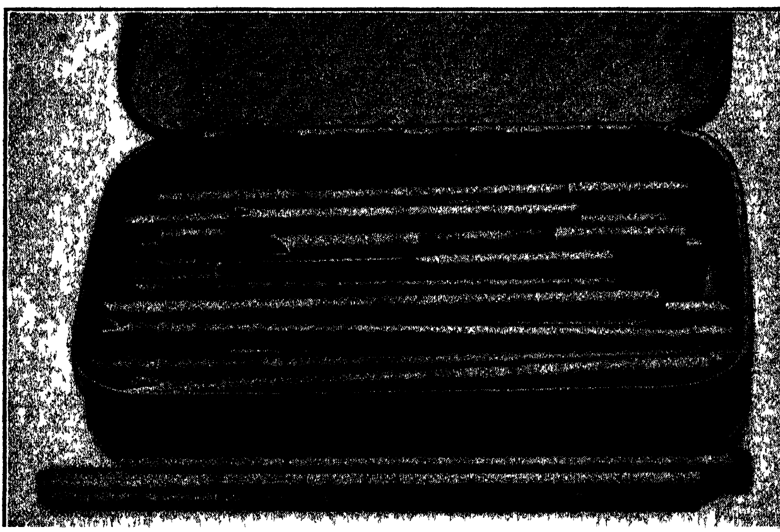


Fig 132.—A set of reamers

diameter ground to size. The work is ground from one end to the clearance cut at the middle and then reversed on centers and ground from the other end. Following the sizing with the wheel, the pins are separated by breaking them apart at the necked dividing line.

These dowel pins are ground perfectly straight from end to end and it is therefore necessary that the holes in die parts be reamed out true and straight. A convenient set of reamers for the purpose is shown in Fig. 132. These are of all standard sizes required for general die construction. They are of the rose type to cut near the end only and are used after the hole is spotted and drilled through with a slightly smaller drill, to remove a very small amount of metal and leave the hole a proper fit for the pins which are ground closely to standard dimensions.

CHAPTER XXV

CONTOUR MACHINES ON DIE WORK

Many die-making methods common to the general shop and also used on production jobs are being followed in connection with war work. These include contour sawing and filing.

Among advanced machines the metal band saw has taken a permanent place. Although its original design goes back several decades, a long period elapsed before it became the adaptable tool now so commonly used in both production plant and tool room. The continuous sawing

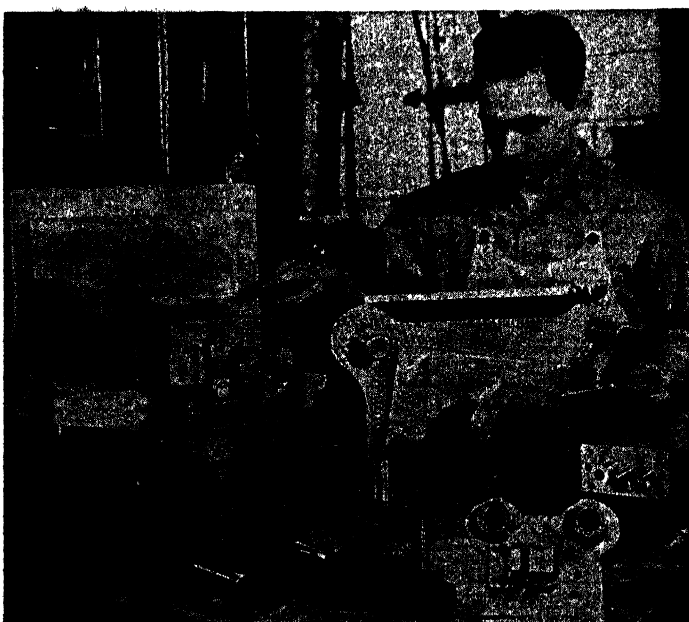


FIG. 133.—Typical group of dies whose construction has been aided by use of contour sawing and filing machines.

and filing machine is one of the latest devices by which the operations of tool room and factory are expedited to a remarkable degree.

Some of the die work produced by these tools is shown in Fig. 133. On the Doall machine, narrow saw bands present a continuous flow of teeth to the work, which may be guided into the saw in curved motion. To cut out odd-shaped holes, the machine is provided with a welder so that the saw may be joined back into a band after one end has been passed through a starting hole in the work.

In the band-filing machine, short segments of the file are mounted on an endless carrier. When the file is at the point of work, it forms a rigid column, and the cutting pressure is applied steadily and continuously.

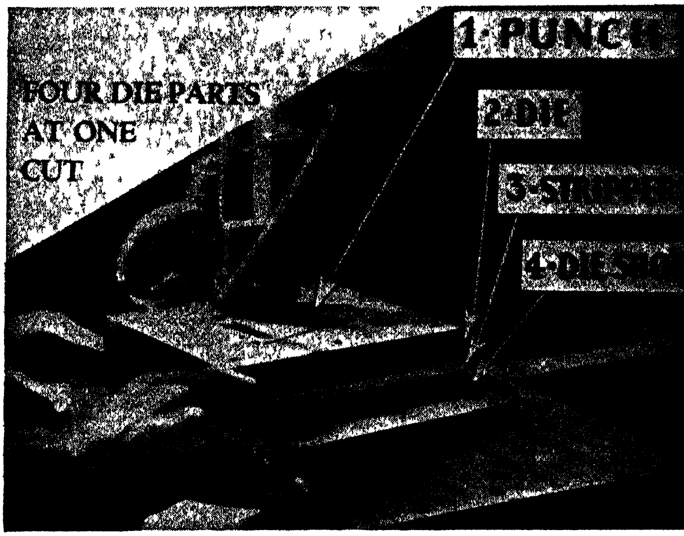


FIG 134 — Simultaneous sawing of punch, die, stripper, and die shoe

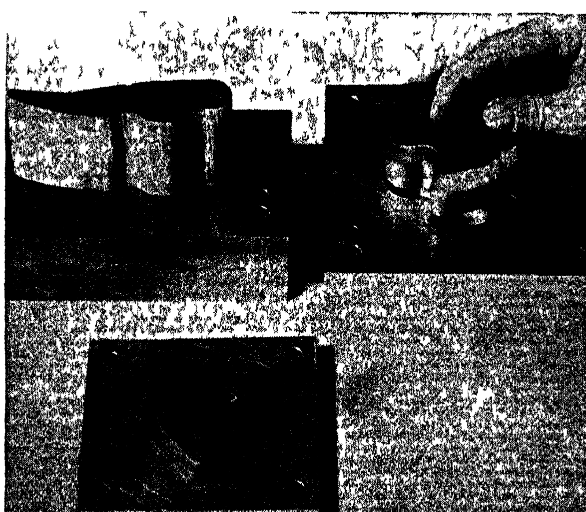


FIG 135 —How slugs cut out of a die block can be used as punches.

The file bands are interchangeable with the saw bands on the Doall machine. In Fig. 134 the contour saw is shown sawing punch, die shoe, die, and stripper at the same time The necessary clearance in stripper and die shoe is attended to after the first sawing operation.

TABLE 3.—DETERMINING DOALL DIE-MAKING TECHNIQUE

Die thickness, in.	Angle of saw starting hole, deg.	Angle for saw cut, deg.	Distance from die-layout line to center of saw kerf, in.	Distance from die-layout line to center of starting hole, in.	Diameter of drill, in.	Width of starting saw, in.	Amount of straight sides on punch and die, in.
1/2	21	18	5/64	3/32	1/8	3/32	3/16
3/4	18	15	4/32	1/8	1/8	3/32	9/32
1	14	11	3/32	1/8	9/64	1/8	3/8
1 1/4	12	9	3/32	1/8	9/64	1/8	15/32
1 1/2	11	8	7/64	9/64	9/64	1/8	9/16
2	10	7	1/8	3/16	13/64	3/16	13/16
3	9	6	5/32	1/4	17/64	1/4	1 1/8
4	8	6	7/32	9/32	17/64	1/4	1 5/8
5	7	6	1/4	5/16	17/64	1/4	2 1/4
6	6	5	1/4	5/16	17/64	1/4	2 1/2

Die thickness, in.	Minimum outside radius, in.	Minimum inside radius, in.	Saw width, in.
1/2	9/32	1/8	3/32
3/4	5/16	1/8	3/32
1	7/16	1/4	1/8
1 1/4	7/16	1/4	1/8
1 1/2	15/32	1/4	1/8
2	11/16	7/16	3/16
3	7/8	9/16	1/4
4	1 1/32	9/16	1/4
5	1 1/16	9/16	1/4
6	1 1/8	9/16	1/4

Owing to the use of a tilting table for the work and a very thin saw blade, the "slug" can actually be employed as a punch in many blanking dies because the contour saw leaves a slit or only $\frac{1}{16}$ in. The clearance can be cut to any desired angle uniformly around the periphery.

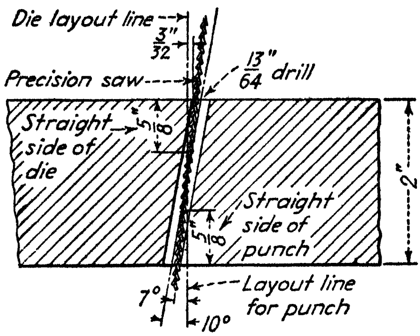


FIG. 136.—Starting hole and saw angle in cutting out die and punch.

The punch and die in the upper part of Fig. 135 are 1 in. thick. The punch and die in the lower left corner of this illustration are $\frac{1}{2}$ in. thick.

If the slug is to be used as the punch, drill the starting hole first, as in Fig. 136. This hole is started *inside* the die layout, and emerges through the die block on the opposite side *outside* the layout line.

The narrow blade of the saw is inserted through the starting hole, its ends are welded together, the table is tilted a few degrees less than the angle at which the hole has been drilled, and the slug is sawed out at this

TABLE 4.—SAW SPEEDS

Material to be cut	Saw velocity, ft. per min.					
	$\frac{1}{16}$ in.	$\frac{1}{4}$ in.	$\frac{1}{4}$ in.	1 in.	1 in.	Over 1 in.
Carbon steel SAE 1010–1095	305	220	220	195	195	150
Nickel steel SAE 2015–2515	210	150	150	125	125	95
Ni-Chrome SAE 3115–3450	125	105	105	75	75	50
High-speed steel	145	125	125	95	95	70
Tool steel oil-hardened	190	150	150	120	120	75
Tool steel air-hardened	150	125	125	95	95	65
Drill rod	....	.....	125	90		
Cast iron	.....	.....	150	125	125	50
Semi-steel	.....	.....	225	200	200	100
Meehanite	150	100	100	80	80	55
Copper (soft)	1,200	800	800	600	600	200
Brass (soft)	1,000	450	450	325	325	250
Aluminum	1,400	1,175	1,175	980	980	625
Dural 14ST	1,400	1,150	1,150	975	975	275
Dural 17ST	1,400	1,200	1,200	1,000	1,000	250
Dowmetal	820	360	360	250	250	190

angle. The path of the saw on the surface is entirely *inside* the layout line. Thus at the proper cutting angle the bottom of the slug that is

to be removed will have material *outside* the layout line. When the punch is removed, the excess material on both punch and die is filed off to make the "land" on the die and the "straight sides" on the punch.

The angle of saw cut and starting hole depends on die thickness. Table 3 gives the angle for the maximum amount of "straight side" on the punch and "land" on the die.

When the punch, or slug, is removed, the layout for finishing the punch is made on the larger end, the contour machine is changed to continuous filing, and the "land" is filed on both punch and die. The punch is then fitted accurately to the die and the latter is secured to the shoe in the usual manner. The punch can be screwed and doweled to the pad, inserted in the pad, or arc welded to the pad.

Table 4 gives saw speeds for a few materials.

Recommended filing speeds are given in Table 5.

TABLE 5.—RECOMMENDED FILING SPEEDS

Material	Filing Speed, Ft. per Min.
Aluminum airplane alloys	140
Brass (soft)	150
Cast iron	110
Cold-rolled steel	90
Copper	150
Drill rod	75
High-chrome, high-carbon steel	50
High-speed steel	60
Machinery steel	115
Monel	110
Tool steel, water-hardened	70
Tool steel, air-hardened	60

Grob open-end band saws. Other well-known metal band saws for tool-room and production purposes are the Grob metal band saw and the Grob open-end saw, designed for small and delicate die work as well as for heavy-duty jobs. An ingenious working principle of the latter machine is the winding of one 140-ft. band saw helically over a drum allowing 2¼ min. of sawing at usual rates of speed. The machine automatically stops when the end of the band is reached, requiring only 20 sec. to rewind to the starting sawing position. A self-tightening eccentric clamp holds the end of the saw blade to the drum and can be quickly released for internal work.

The same company's continuous filing and lapping machines make use of sectional file chains, which are of a simple self-locking type. Lapping stones are also quickly changed. Figure 137 shows a typical die job on the filing machine, and Fig. 138 shows a group of types of file.

FIG. 137.—A die-filing job on a Grob machine.

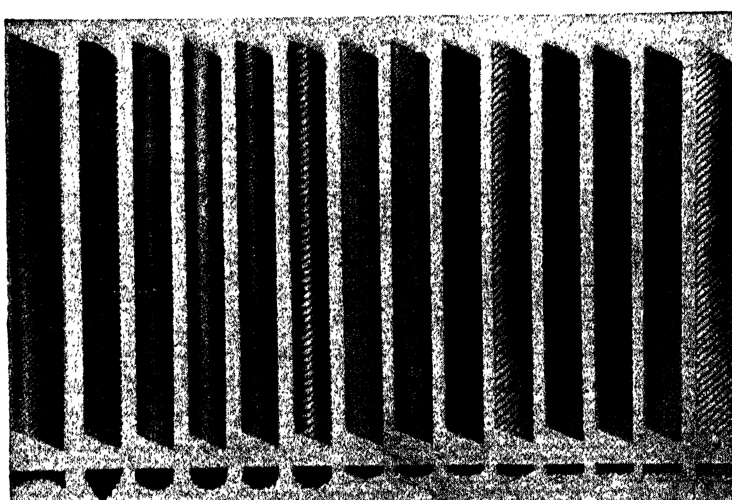


FIG. 138.—Grob file types.

CHAPTER XXVI

SOME HARDENING PRINCIPLES APPLIED TO DIES

After every effort has been expended by the die maker in the production of an accurate set of dies, his labor may all prove wasted because of improper treatment of the work in the hardening process. There is probably less definite information available upon this general subject of hardening, than on any other branch of the work. There are also more cases of die failure traceable to improper hardening than to any other cause.

A well-known authority on this subject, Edward Dean, has set down certain principles in connection with the finishing and hardening of high-carbon steel dies that should prove of benefit to every one engaged in this line of work. The conclusions drawn have been based upon twenty years of research work in this direction, during which time a large number of observations were made enabling the investigator to form certain definite opinions as to the action of dies in the hardening process and conclusions as to the reasons for various failures when certain tools were placed in service.

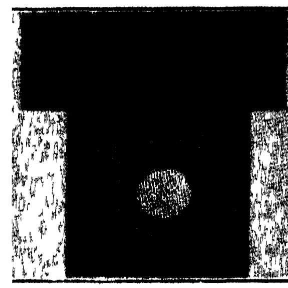
All of the work referred to here was done on commercial die steels from 96 to 110 point carbon. All dies referred to were heated for hardening in a gas fired furnace and quenched in clear water at about 85° F.

As this authority points out, we are apt to think that a piece of tool steel hardens all through. It is of course true that a piece of hardened high-carbon tool steel is harder throughout after hardening than when it was soft. It is equally true that such a piece of steel having a section thicker than say $\frac{1}{4}$ in. has several different degrees of hardness. In a manner it resembles a piece of hardened carbonized soft steel in that it has a very hard shell and gradually grows softer as the core is approached, although the differences in hardness between the various layers are much less than in the case of the hardened carbonized low-carbon steel.

As an illustration it is pointed out that if a piece of high-carbon tool steel, say $\frac{3}{8}$ in. thick, 1 in. wide and 2 in. long, is hardened, it will be found to have a soft core surrounded by a harder shell as indicated by Fig. 139.

The difference in hardness between the two areas is some 3 to 5 points on the scleroscope scale, the actual readings running from 92 to 96 for the shell and from 89 to 93 for the core. The specimen illustrated was prepared from a piece of 98-point carbon steel heated to 1410° F., quenched until cold in water at 85° F., drawn in oil to a temperature of 440° F., and

then ground away ¼ in. on one edge. This ground surface was then polished with several grits of successively increasing fineness, the last one used being Turkish rouge. After the final polishing the surface was etched for about 40 seconds with a 7 per cent solution of iodine. After careful washing in alcohol it was allowed to remain in the air for a few seconds until oxidation commenced. It was then at once coated with white vaseline as a preservative. This method of preparing and keeping the steel specimens for microscopic study is one that was regularly followed in these investigations. The 7 per cent solution of iodine can be bought at any drug store. The white vaseline is found a better preservative than any of the oils, for the reason that it is free from acid.



FIGS. 139-140.—Section of specimens of hardened die steel showing layers of different hardness.

Figure 140 illustrates a block of steel 1 in. square treated in the same manner as the piece in the preceding view. The difference in hardness of the two areas on the scleroscope scale is about 3 to 5 points.

To show more clearly the relationship between the subdivisions of the shell and core, Fig. 141 is presented. This diagram is typical of the polished and etched surfaces of the specimen in Fig. 140.

In Fig. 141 the hard outer shell is indicated by the dark border *A*. Directly inside this is a white line *B*. Inside of *B* is a faint shadowy border *C* of about the same width as *A*. And inside of border *C* is the soft center *D*.

In considering the structure of a die with an attempt to state the results that will come from using a die having these various areas of hardness, the following outline seems to be true: The best service will come from the hard border *A* of Fig. 141. This, in a properly hardened piece, is about $\frac{1}{16}$ in. wide up to the line *B*. Beginning with the line *B* and running inward toward the center *D*, the structure is such that grooving or rapid wear may take place if a part of the die having this structure is used as a cutting edge. In some unsuccessful dies the white line *B* has been found as close as 0.010 in. from the cutting edge and it has even run clear to the edge. It is evident that such a die was either improperly designed or improperly made and hardened to give maximum results.

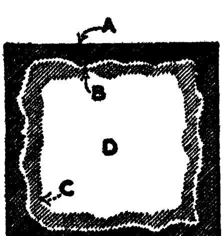


FIG. 141.—Areas of different hardness in die steel.

To further illustrate this point the authority quoted refers to a die shown in Fig. 142 which exhibits all the lines of the specimen in Fig. 140 except that the white line corresponding to the border *B* of the diagram,

Fig. 141, is broken and the center color runs clear through the hard border to the cutting edge. When on test in the press, this die ran only 1 hour at a cutting speed of 480 strokes per minute when it became dull and grooved at the points where the center color ran out to the edge.

The history of this die was investigated and it was found to have been improperly hardened, having been dipped with the grooved face down instead of vertical and moved rapidly with an up and down motion. This allowed steam and vacuum pockets to form in the groove, preventing

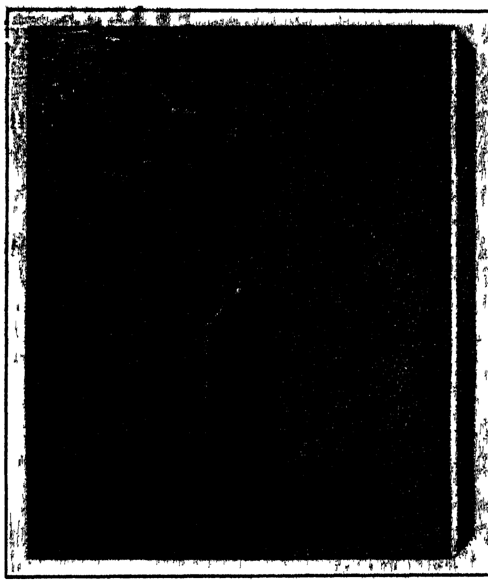


FIG. 142.—Notching die, showing hardness lines on surface

the cooling water from reaching the surface, creating the soft spot that later scored when the die was placed in service.

A duplicate of this die made from the same steel at the same time and hardened the same way also ran only 1 hour under test. It was then removed, annealed, refaced, and properly hardened. The hardening this time consisted in dipping it with the grooved face vertical and moving it in such a way and at such a rate that neither steam nor vacuum pockets could form in contact with the surfaces that later on were to form cutting edges. This die was then put to test and ran for 11 hours at a speed of 480 strokes per minute. The first die cut only some 20,000 holes before grooving and dulling. The second die cut about 220,000 holes before dulling. These records show two things. First, the possibility of greatly increasing the service of dies if they are properly made, and second, the importance of obtaining the hard outer shell of hardened high-carbon tool steel on all surfaces that are to furnish cutting edges.

Die Hardness Affected by Proportion

After the tests mentioned, search was made to discover other conditions that might produce soft areas in the surfaces that must supply the cutting edge. This resulted in bringing out two factors that have a decided influence upon the thickness and relationship of the various hardness layers outlined in the diagram, Fig. 141.

One of the troublesome problems was the hardening of small holes and openings in the dies. If dies are to be made to give maximum service, permitting them to be worn down from 1 in. thick at the outset to $\frac{1}{8}$ in. at the end, it is evident that the inside of all of the openings for cutting edges must be uniformly hard from top to bottom. That this condition did not exist in many dies as ordinarily made has been proved time and again. Often a die would start by giving excellent production records for the

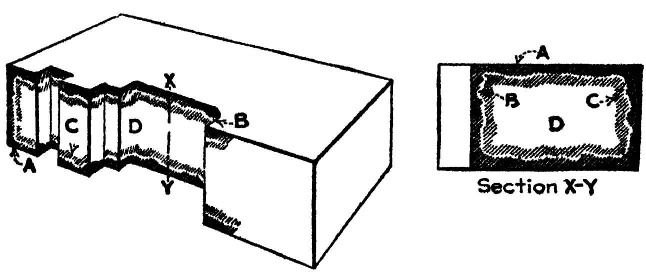


Fig. 143.—Diagrammatic section of a solid die, showing areas and lines of hardness.

first few grindings; then these records would begin to change, giving fewer and fewer blanks per grinding until only one-quarter or even one-tenth as many were being produced as at first. If the die was kept at work, these records would begin to improve after having reached a low point, and perhaps come back to an amount nearly if not quite equal to that produced at first.

The conclusion arrived at as to the cause for this is indicated by Fig. 143. The outer surfaces of the die from which the heat could be easily abstracted in quenching possessed the proper thickness of hard shell. But as the middle of the original length of the hole is approached the heat could not be abstracted rapidly enough in cooling and a place is found where the hard shell is comparatively thin and cannot stand up to give maximum service. Actual differences in hardness over the surface of a die are plainly shown by Fig. 144.

From this condition it is concluded that there was too much heat per square inch of surface area in the hole to produce satisfactory hardening. It is probable that the length of time required for the heat to flow out has an important effect upon the thickness and character of the hard layers. Thus in designing dies it is important to proportion them so that an

excessive amount of heat will not be compelled to flow through surfaces that later on are to form cutting edges.

This is called, by Mr. Dean, the principle of proportion in die design. In Fig. 145 is a die which, as he points out, has had a number of round holes drilled through it for the purpose of giving proper proportion. In fact all the holes except the slots are for the purpose of obtaining proper proportion to control hardening. These holes are so located as to

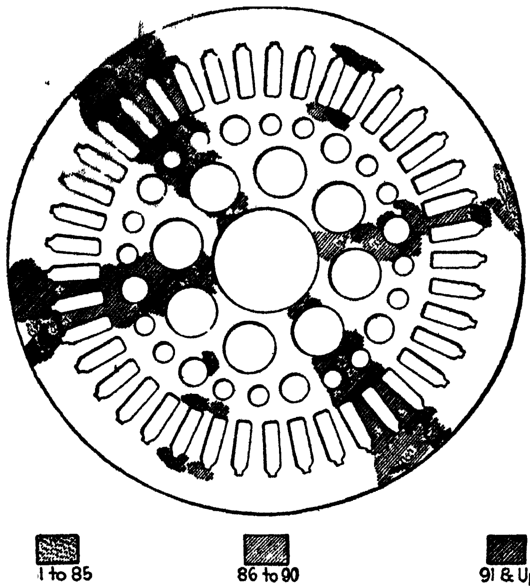


FIG. 144.—Difference in hardness over surface of a large hardened die.

bring only a comparatively small mass of solid metal around each working slot and so that the heat from every section around a working hole must be able to flow in at least two directions to quenching surfaces, provided one of these surfaces is that of a working hole or opening.

INFLUENCE OF FINISH ON DIE HARDENING

The second factor which has a very marked influence upon die hardening and upon the thickness and uniformity of the outside hard shell is the surface finish. For a number of years the authority quoted had standardized surface finishes that were required for all dies. Because of the decarbonization and oxidation that take place when heating a die, a thin, almost imperceptible coating of scale forms on the surfaces. The thickness and nature of this scale and the ease or difficulty with which it is cast off when the steel is immersed in water have a decided influence upon the hardness. The ideal condition is one where the scale is very thin, is uni-

form all over the die, and is cast off as soon as the steel enters the quenching water.

It is easy to make a simple test showing this thin scale. Take a small white porcelain dish, fill it with clear water, heat a piece of steel and then immerse it. The thin scale can be seen to float away from the surface of the steel. Microphotographs magnified to 1,200 diameters show openings or fissures through the scale, and also a multitude of tiny cables holding this scale to the surface of the steel. The intervening space was filled with steam when the shell was hardened, thus preventing the free flow of heat and interfering with the hardening process.

The most detrimental finish to successful hardening seems to be a tearing cut with a fine feed and a dull tool, such as can be produced in the

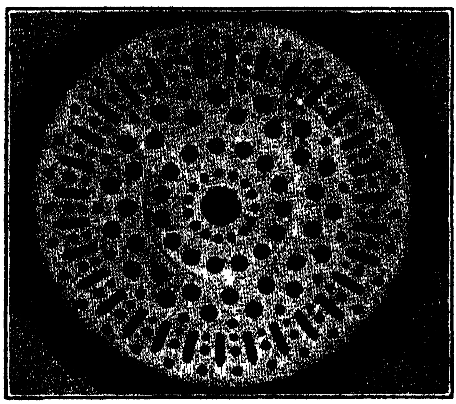


FIG. 145.—Die with proportion holes for hardening properly.

lathe, planer, or shaper. A certain specimen shows scratches made on two faces of a steel block 1 in. square. One side was finished smooth, the other so as to produce steam pockets. The block was hardened at 1410° F. and 0.002 was ground off each face after hardening. Each face was then scratched by a fine needle mounted in a steel ball; this needle was merely drawn across the ground faces without applying any pressure except that of the weight of the ball. The face that was finished with a surface suitable for hardening shows no scoring or scratching from the needle. On the other hand, the scratches on the other surface are very noticeable.

In order to obtain satisfactory commercial results in die hardening, the finish on dies has been standardized to one which is equal to that obtained from a No. 2 Swiss file on a flat surface. There is a difference of about one number between the grades of the imported Swiss files and the American Swiss. The No. 1 American is nearly equal to the No. 2 imported. Each leaves about the same grade of finish on the work.

A flat file will leave a smoother finish than a round or half-round file of the same number and cut. If one looks closely at a half-round file, he will see that it presents a series of small corners to the work instead of a smooth cutting edge. To test the various kinds of finish, take a piece of tool steel $\frac{1}{2}$ in. thick and file it with a No. 2 Pillar file until the surface is straight and smooth. Then take a $\frac{1}{4}$-in. No. 2 round file and file a half-circle about $\frac{1}{8}$ in. deep in the steel. The edge where the half-round groove meets the top flat surface will look like a saw when examined under the microscope. The other straight edges that have been filed will show smooth and even.

A No. 4 half-round file will leave approximately the same finish on a curved surface as a No. 2 flat file will leave on a straight surface. It is important to give a half-round file a slight rotating motion during the forward stroke of filing.

Too high a finish or polish on a die seems to have the effect of repelling the water when the piece is immersed for hardening. The quality of the finish should be neither too coarse nor too fine, though at all times a toolmaker should be careful not to confuse smooth finish with flat finish. A piece of steel with a corrugated surface, or one cut with a coarse feed, will harden successfully if the surface of the corrugations or feed marks is smooth; and, in fact, it will present more cooling surface to the water than a flat surface. At the same time, unless such a piece is moved in the water in such a way that the liquid flows lengthwise of the grooves, steam pockets are likely to form and unequal cooling take place.

OTHER HEAT-TREATING POINTS[1]

Figure 146 shows a punch which has a heavy body but a thin punch section. During the hardening of such a punch, the thin punch section will absorb the heat of the furnace more rapidly than the heavy body. The quenching will also be very detrimental, as the thin section is cooled off much faster than the heavy body of the punch, thereby establishing internal stresses.

To eliminate cracking or distortion through these stresses, loose pieces of plain machine steel should be wired or bolted to the punch, as shown in Fig. 146. These machine-steel pieces will prevent the heat from being absorbed too rapidly by the thin section of the punch, and will thus prevent it from being overheated. The protecting machine-steel pieces will also prevent the thin section from being cooled faster than the heavier punch body, thereby overcoming the detrimental quenching action which would cause distortion and cracking of the punch.

Figures 147 and 148 show punches of a blank die which were being machined from a tool-steel block as shown by the dotted outline. The

[1] By Walter Kassebohm.

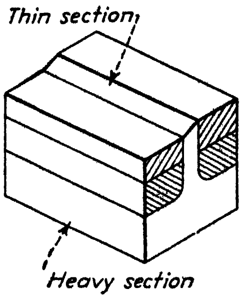


FIG. 146.

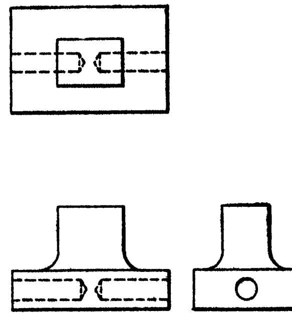


FIG. 151.

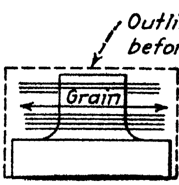


FIG. 147.

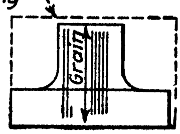


FIG. 148.

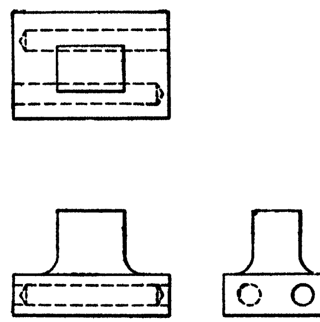


FIG. 152.

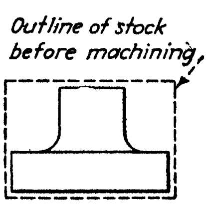


FIG. 149.

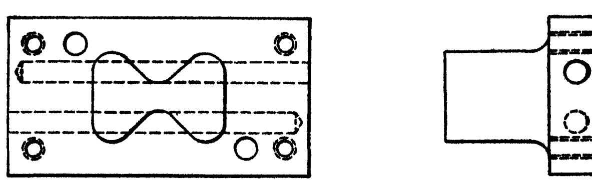


FIG. 153.

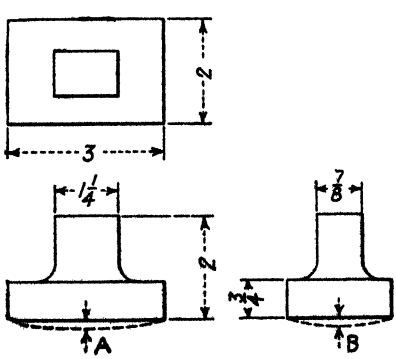


FIG. 150.

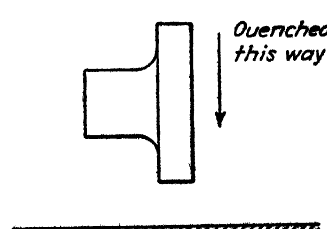


FIG. 154.

FIGS. 146–154.—Practical heat-treating of press tools.

grain of the tool-steel blocks is indicated to show how the tool steel was cut from the bar stock. In order to save material, no metal was removed from the tool-steel block at the bottom of the punch, as shown in Fig. 147, and on one side of the punch, as shown in Fig. 148. Such a practice will, most likely, develop trouble during the heat-treating process of the punches because tool-steel bars have in most cases a decarburized layer of material on the outside of the bar. Punches that are finished as shown in Figs. 147 and 148 will distort during the heat-treating process because the outside layer of the tool steel, which was not machined off, has different hardening qualities than the steel which had the outside layers removed all around. It is, therefore, important that tool parts which are made from tool steel and hardened should have the decarburized outside layers of the tool steel removed from all sides, as shown in Fig. 149.

Figure 150 shows a punch with a heavy heel which will most likely bulge, as shown by the dotted outline, when being hardened. Such a bulge of the heel can be explained when considering that all corners are cooled first during the quenching process, thus setting up internal stresses through the delayed cooling of the actual center of the large heel or punch body.

In order to overcome the internal stresses, holes can be drilled into the heel of the punch, as shown in Figs. 151 and 152. Instead of bulging the heel of the punch, the holes are being collapsed during the quenching process, as can be verified by the following notes of actual experiments:

Type of steel:

0.85 to 0.90 C	1.05 to 1.25 Mm
0.20 to 0.35 Si	0.40 to 0.60 Cr

Slow preheat; fast heat to 1475°F. in muffled furnace without atmospheric but with accurate gas mixture and temperature control.

Quenched in medium light oil: quenched as shown in Fig. 154.

Drawn at 400°F.; hardness Rockwell C61—63.

Result:

	A	*B*
Punch as per Fig. 150 (no stress relief holes) . .	0.0025	0.003
Punch as per Fig. 151	0.0002	0.0000
Punch as per Fig. 152	0.0001	0.0001

The above-mentioned three punches had identical over-all dimensions, as shown in Fig. 150. Extreme care was exercised in the cutting of the tool-steel bar stock, machining, heat-treatment, and drawing so as to have the best possible identical conditions in the handling of the

punches to secure reliable results that could be used for establishing the above dimensions *A* and *B*, as shown in the table.

It was shown by the experiments and proved many times in actual practice, that distortion of heavy-bodied tool parts similar to the punches, as shown in Figs. 150, 151, and 152, can be overcome by the adding of stress-relief holes. It will be found that such holes, which are round before hardening, are from 0.001 to 0.004 inch oval after the tool-steel punch is hardened. Attention should be paid to the fact that stress relief holes should not interfere with screw or dowel holes, as shown in Fig. 153.

POINTS IN QUENCHING TOOLS

Steel should come from the quench clean and hard to the very surface. To accomplish this, the atmosphere of the furnace and the time the piece is in the furnace must be considered. To prevent decarburization of some tool steels in heating, it is necessary to create a slight oxide upon the surface. If this oxide is too thin, the piece will decarburize; too thick, it will destroy the accurate surfaces of the piece, causing it to lose size and interfere with the quenching steel. On this subject R. E. Geisert says that furnace atmosphere appears to affect more than mere surface. In some steels it appears to affect the physical quality clear through with a very noticeable decrease in hardness under improper furnace atmosphere.

The quenching equipment depends, of course, upon the work handled, but the heat-treater should not be limited in quench equipment. Often the saving of a single tool will pay for the entire quench equipment. Whether the quench is water, oil or air, it should be such that the heat-treater may cool uniform or ununiform, as desired, or he may concentrate the quench upon a certain surface. This will necessitate still- and flush-quenching equipment and will require some special flushing fixtures. The cost of these fixtures is small when one considers that tool life can sometimes be increased severalfold by flush quench.

For example, a certain cold swaging operation was giving considerable trouble. These dies were made from water-hardening steel quenched in a still brine bath and drawn to 400°F. for 2 hr. After about 20,000 pieces these dies cracked and chipped. New dies were made, quenched the same way, but drawn to 475°F. These dies failed on less than 20,000 pieces. A close inspection of the die and parts made in it revealed the center had gradually sunk; eventually small cracks appeared; and from these small cracks a chipping-off occurred. Then someone got a hunch. Another set of dies was made of the same steel, the hardening temperature was raised in order to increase the hardening penetration, but not to a point to impair grain size. A flush quench, Fig. 155 was arranged to a water tap and the dies quenched from an area a little larger than the working

area, the rest of the die remaining dry. These dies were then drawn to 350°F. for 1 hr. The working face of these dies showed a Rockwell reading of C63, while the back could be filed quite freely. These dies were finally replaced because of wear, after they had produced slightly over 800,000 pieces.

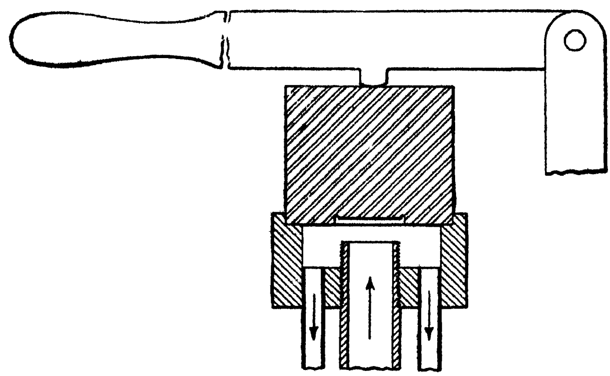


FIG. 155.—Internal fixture for quenching embossing dies.

Another example of flush quench was the punch of a compound die that blanked and formed a brass cap about 1 in. in diameter with a $\frac{5}{16}$-in. flange. It was necessary to pinch this flange slightly. The punch would only produce a limited number and then split. It was drawn to a higher

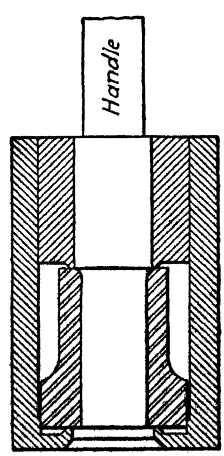


FIG. 156.—Internal fixture for oil-quenching-compound punch.

temperature, but then it soon roughed and scored the caps. A punch was made from an oil-hardening steel and a fixture was made to oil-quench from the inside, as in Fig. 156. At first, fear was expressed that the punch would not harden on the outside sufficiently to hold an edge,

but nevertheless it might be worth trying. The punch was oil-quenched and drawn to 300°F. It was found to be file-hard on the outside, and it shrank a little in diameter, but this did not matter, as material was left for grinding. The punch was then ground and put into service. It never broke, but finally wore out with the rest of the die long after everyone had forgotten the number of pieces it had produced.

Another example was draw rings, Fig. 157, quenched all over and drawn to 375 to 400°F., Rockwell C62 or 63. If left harder, they would break in service. Occasionally some would fail when drawn as low as 62 or 63 Rockwell. Quenching through the hole was tried on several

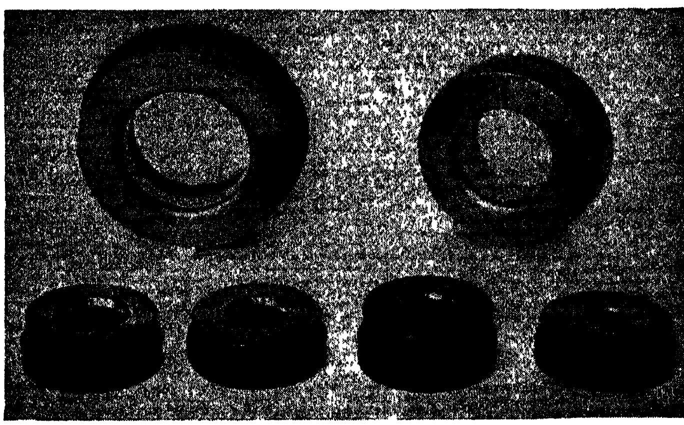


FIG. 157.—Draw rings. Such die parts need particularly careful treatment in furnace and quench. The smaller rings are for latch-housing shells.

rings, then they were drawn for 4 hr. at 300°F., Rockwell 65 to 66. These rings gave no trouble with breakage. The next batch was quenched the same way but drawn to 200°F. for 6 hr., Rockwell 66 to 67.5. No breakage has occurred so far, but a substantial increase was made in shells per ring-polish.

Do not assume that flush quench is the only method; the still quench will handle most work. These are the possibilities of favorable hardening strains. It must be remembered too that even when quenching fixtures are used to get favorable strains, unfavorable strains may develop in another direction.

STEELS FOR VARIOUS CLASSES OF DIES

Tables 7 to 14 inclusive give specifications for the die steels referred to in Table 6, as recorded in the *American Machinist* by H. R. LeGrand, through courtesy of Western Electric Company. Table 15 shows another schedule of die-steel specifications; these are from the General Electric Company.

TABLE 6

Type of tool	Number of steel	Hardness Rockwell C
Adapters, punch and die	13–15	55–58
Adapters, punch press	19	55–58
Arbors, forming die	11–15	63–66
Arbors, forming die, frail	11–13	53–56
Backing plates, heading	15	55–58
Backing plates, punch and die	13–15	57–60
Blades, cut-off, heading	15	Cutting edge 61–64 Back edge Spring temper
Blades, shear	1	66–64
	13–15–28	59–62
Bushings, guide	19	63–66
Bushings, guide post	19	61–64
Bushings, perforator	11–13–15	60–63
Bushings, stripper	11–13–15	60–63
Dies, blanking, stock under $\frac{1}{16}$ in.	1	60–64
	13–15	60–63
	25	58–62
Dies, blanking, stock over $\frac{1}{16}$ in.	1	60–64
	13–15	62–65
	25	60–64
Dies, blanking, permalloy, silicon steel, mica	1 or 28	60–64
Dies, clipping	13–15	60–63
Dies, drawing, stock under $\frac{1}{16}$ in.	1	60–64
	13–15	63–66
Dies, drawing, stock over $\frac{1}{16}$ in.	1	60–64
	13–15	61–64
Dies, embossing	13–15	60–63
Dies, forming, stock under $\frac{1}{16}$ in. stock over $\frac{1}{16}$ in.	13–15	60–63
	13–15	63–66
Dies, heading, straight holes no cavities radius, no	15	62–65
With radius or cavities	15	59–62
With square recess	15	57–60

Type of tool	Number of steel	Hardness Rockwell C
Dies, hot forming and swaging	5	54–58
Dies, knife edge	15, 23 or 25	53–56
	28	52–56
Dies, notching	13–15	62–65
Dies, perforating:		
Brass or steel under $\frac{1}{16}$ in.	13–15	60–63
Brass or steel over $\frac{1}{16}$ in.	13–15	57–60
Bronze under $\frac{1}{16}$ in.	13–15	60–63
Bronze over $\frac{1}{16}$ in.	13–15	58–61
Rubber and Permalloy under $\frac{1}{16}$ in.	13–15	60–63
Rubber and Permalloy over $\frac{1}{16}$ in.	13–15	58–61
Dies, shaving	13–15	60–64
		61–64
Dies, swaging	23	62–66
Draw rings	1	60–64
	13–15	62–65
Hammer blocks, swaging	23	62–65
Knock outs	15	57–60
Pads, embossing-die	13–15	60–63
Forming die, light work	13–15	57–60
Forming die, heavy work	13–15	60–63
Spring, for inserting punch	11	57–60
Perforators:		
To $\frac{3}{32}$ in. diam.	1	57–61
	11 or 13	51–54
	28	60–64
$\frac{3}{32}$ to $\frac{3}{16}$ in.	1	57–61
	11 or 13	57–60
	28	60–64
$\frac{3}{16}$ in. diam. and over	1	57–61
	11 or 13–15	60–63
	28	60–64
Perforators for Permalloy	1, 11, 13 or 28	57–60
Perforators for embossing	11 or 13–15	58–61

TABLE 6.—(*Continued*)

Type of tool	Number of steel	Hardness Rockwell C	Type of tool	Number of steel	Hardness Rockwell C
		All heads of	Heading	15	58–61
		perforator and	Hot forming	5	56–60
		pilot spring	Hot swaging	5	56–60
		tempered	Inserting, heading	15	57–60
Pilots	11 or 13–15	57–60	Knife edge	13–15	Spring temper
Plungers, inserting punch	11 or 13	57–60	Notching	13–15	60–63
Plungers, knock out	11 or 13–15	57–60	Perforating, under $\frac{3}{32}$ in.	1	60–64
Punch, plates	1020 or 13–15	56–59		11 or 13	57–60
Punches:			$\frac{3}{32}$ in. and over	1	60–64
				13–15	60–63
Blanking, stock under $\frac{1}{16}$ in.	1 or 28	60–64	Riveting	11 or 13–15	57–60
	13–15	58–61	Shaving	1	60–64
	25	60–63		13–15	62–65
Blanking, stock over $\frac{1}{16}$ in.	1 or 28	60–64		23	61–65
	13–15 or 25	60–63	Shearing	13–15	59–62
Broaching	13–15	60–63	Staking, heavy-duty, large cross sections	13–15	59–62
Clipping	13–15	60–63	Staking, light-duty, small cross sections	13–15	56–59
Drawing:			Swaging and bumping	23	60–64
Stock under $\frac{1}{16}$ in.	13–15	60–63	Push pins	11 or 13–15	56–59
Stock over $\frac{1}{16}$ in.	13–15	63–66	Stops, auto punch and die	13–15	57–60
Embossing	13–15	58–61	Stops, finger punch and die	1020	file hard
Flattening	1, 13–15 or 28	63–66	Strippers	1020 or 13–15	53–56
Forming:			Yokes for punch and die	15–19	55–58
Stock under $\frac{1}{16}$ in.	13–15	61–64			
	25	60–63			
Stock over $\frac{1}{16}$ in.	13–15	63–66			
	25	60–63			

TABLE 7.—CARBON TOOL STEELS MOST FREQUENTLY USED

Type	Min.	Max.
Carbon, No. 13	1.20	1.30
Carbon, No. 14	1.10	1.19
Carbon, No. 15	1.00	1.09
Manganese	0.25	0.40
Silicon	0.10	0.40
Phosphorus	....	0.025
Sulphur	....	0.025
Chromium—none desired	....	0.10
Vanadium—optional	....	0.25

Brinell hardness: minimum 160; maximum 190; desired 180.

Cleanliness and degree of spheroidization covered by micrographic standards.

TABLE 8.—NO. 19 CARBON TOOL STEEL

Type	Min.	Max.
Carbon	0.90	1.05
Manganese	0.25	0.50
Phosphorus	....	0.04
Sulphur	....	0.05

Brinell hardness: minimum 160; maximum 190.

TABLE 9.—NO. 11 CARBON TOOL-STEEL DRILL ROD

Up to $\frac{7}{16}$ in. in diameter

Type	Min.	Max.
Carbon	1.17	1.35
Manganese	0.30	0.47
Silicon	0.10	0.25
Phosphorus	....	0.025
Sulphur	....	0 025
Chromium*	....	0.10
Over $\frac{7}{16}$ in. in diameter		
Carbon	0 95	1.05
Manganese	0 30	0.47
Silicon	0.10	0.25
Phosphorus	....	0 025
Sulphur	....	0 025
Chromium*	....	0 10

* None desired.

Steel must be readily machinable.

TABLE 10.—NO. 1 HIGH-SPEED TOOL STEEL

Type	Min.	Max.
Carbon	0 65	0.75
Manganese	0.10	0 40
Sulphur	...	0.035
Phosphorus	...	0.035
Silicon	0.15	0 35
Chromium	3.50	4 50
Tungsten	17 00	19.00
Vanadium	0 80	1 10

Brinell hardness: minimum 200; maximum 245; desired 230.

TABLE 11.—NO 5 HOT-WORK TOOL STEEL

Type	Min.	Max.
Carbon	0.40	0.50
Manganese	0.15	0.35
Sulphur	....	0.03
Phosphorus	....	0.03
Silicon	0 10	0 30
Chromium	3.00	4.00
Tungsten	10.00	15.50
Vanadium	0.15	0.90

Brinell hardness shall be lower than 248.

TABLE 12.—NO. 23 FINISHING STEEL

Type	Min.	Max.
Carbon	1 25	1.40
Manganese	0.25	0.35
Silicon	0 15	0.50
Phosphorus	....	0.025
Sulphur	....	0.025
Tungsten	3.50	4.40
Chromium	0.15	0.80
Vanadium	Optional	

Brinell hardness not more than 235.

TABLE 13.—NO. 25 NONSHRINK, OIL-HARDENING TOOL STEEL

Type	Min.	Max.
Carbon	0.80	0.95
Manganese	1.10	1.30
Silicon	0.20	0.35
Phosphorus	....	0.025
Sulphur	....	0.025
Vanadium		
Chromium	0.40	0.60
Tungsten	0.40	0.60

Brinell hardness below 212 is desired.

TABLE 14.—NO. 28 HIGH-CARBON, HIGH-CHROME TOOL STEEL

Type	Min.	Max.
Carbon	2.10	2.60
Manganese	0.20	0.35
Phosphorus	.....	0.025
Sulphur	.....	0.025
Silicon	0.20	0.50
Chromium	10.00	13.00
Vanadium (optional) but if included	0.05	0.15

Brinell hardness not more than 248.

TABLE 15.—GENERAL ELECTRIC SPECIFICATIONS FOR DIE MATERIALS

Steel	Composition	Application
1. High-carbon steel	Carbon 1.10 Manganese 0.25 Silicon 0.20	Cutting, forming, and drawing dies for low and medium production; material selected because of low cost, good machining qualities, and intense hardness. Used for designs not likely to crack or warp excessively when water-quenched.
2. Low-alloy oil-hardening steel.	Carbon 0.85 Manganese 0.32 Silicon 0.38 Chromium 1.67 Vanadium 0.06 Tungsten 0.56	Cutting, forming, and drawing dies and for cold-stamping and coining operations that require greater depth of hardness, and better resistance to cracking and warping as compared with steel No. 1.
3. Air-hardening high-carbon high-chromium.	Carbon 1.50 Manganese 0.30 Silicon 0.50 Chromium 12.0 Vanadium 1.0 Molybdenum 1.0	Cutting, forming, and drawing dies for highest production or where minimum warpage and danger of cracking in hardening are required. For drawing and forming dies this material is usually furnished in the cast form.
4. Machine steel		Low-production dies, such as simple push-through types and for various parts of dies where case-hardening material is suitable. The material is treated by the cyanide process when a case less than 15 mils thick will suffice and by the pack-hardening process when greater case depth is necessary.
5. Electric furnace cast iron	Carbon 3.00 Manganese 0.75 Silicon 2.00 Molybdenum 0.50	Drawing and forming dies for low production and for die-casting dies for zinc and aluminum alloys.
6. High-carbon steel	Carbon 0.95 Manganese 0.45 Silicon 0.35	Cold-headed dies.
7. Chrome-nickel molybdenum steel.	Carbon 0.40 to 0.60	Forging and hot-heading dies. The forging die blocks are heat-treated by the manufacturer to specified Brinell hardness ranging from 325 to 425, and the impressions are machined in this treated material.

LIST OF REFERENCES

NOT DIRECTLY REFFPRED TO IN PREFACE OR TEXT

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